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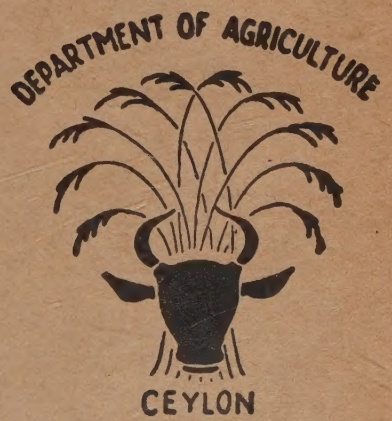

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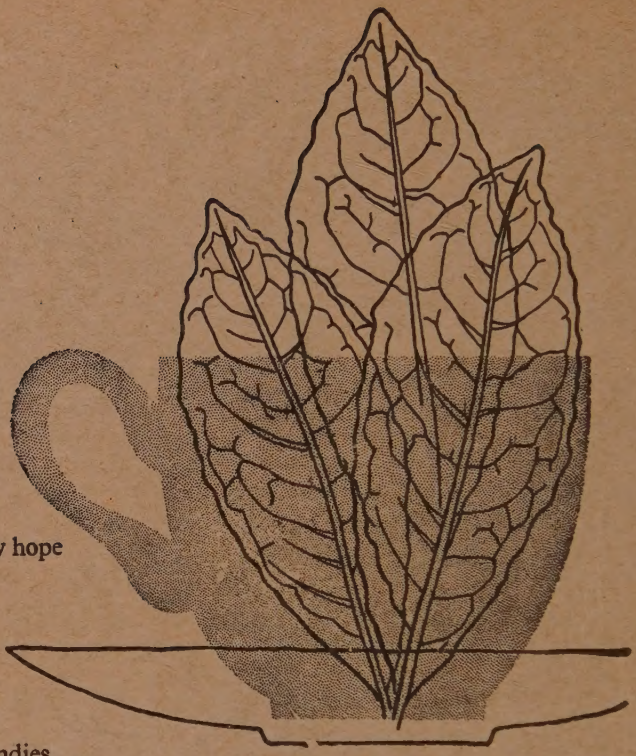

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TROPICAL AGRICULTURIST

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(1) Manuscripts for publication should be typewritten on one side of the paper at double spacing and sent in duplicate to the *Editor, Tropical Agriculturist, Department of Agriculture, Peradeniya, Ceylon.*

(2) Articles should be divided into sections, each headed by a caption, and concluded with a brief summary, if necessary.

(3) Text figures and photographs must be (*a*) suitable for reproduction, (*b*) supplied with legends typed on separate sheets of paper, and (*c*) separate from the text but allocated to sections of the text.

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(5) Titles of manuscripts should be brief.

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EDITORIAL

Dr. A. W. R. Joachim, O.B.E., B.Sc., Ph.D. (Lond.), F.R.I.C., Dip. Agric. (Cantab.)

Director of Agriculture

(January, 1951-August, 1956)

AFTER A LONG and distinguished career in the Department of Agriculture, Dr. A. W. R. Joachim retired on August 17, 1956. To him must go the credit of being the first Ceylonese who preferred to venture in the field of scientific agriculture rather than be attracted to the usual professions of law, medicine, engineering and the Civil Service, which most young men who had the opportunities of studying abroad followed.

The award of the 1917 Ceylon Government University Scholarship in Science on the results of the London Intermediate examination in Science which was held externally in this country prior to the establishment of a University went to A. W. R. Joachim. It entitled him to a University training in the U. K. and leaving Ceylon in 1919, he joined University College, London, where he studied Chemistry. He received his degree in that subject in 1921 and then proceeded to Cambridge to take the two-year course for the Diploma in Agriculture with soil science as his special subject. Whilst in England he took the opportunity of spending some time at the Rothamsted Experiment Station where he gained familiarity with the techniques of soil science.

Returning to Ceylon in 1923, the Scholar joined the Department of Agriculture and for a couple of years, while the Chemical laboratory at Peradeniya was being built, worked as an Administrative Assistant in the Director's office. After his appointment as Chemist, he plunged actively and with considerable zeal into research and five years later received the Ph.D. degree of London University for his investigations on green manuring. For over twenty years, Dr. Joachim with his two assistants strove to study the fundamental problems on Ceylon soils and their fertility, and they also carried out extensive analysis of the nutritional values of foods grown in Ceylon. Numerous soil surveys were undertaken including the examination of the soils of all major Colonization Schemes for their suitability for cropping with irrigated paddy. During this period, there was almost a continuous flow of published papers on investigations carried out in the Chemical Division, particularly on soils and the manurial requirements of crops. Dr. Joachim's name, however, will always be remembered by the outside world for his pioneer work on the classification of Ceylon Soils and his Provisional Soil Map of the Island.

In 1947, this active soil scientist was promoted to the post of Deputy Director and in 1951 he became Director. He was the first Ceylonese technical officer to rise to these two positions. In his official capacity as Director, he was also Editor of this journal, the Chairman of the Central Board of Agriculture and the Chairman of the Coconut Research Board. During his tenure of office as Director, he was anxious to see an improvement in the financial position of all the Agricultural Stations and Livestock Farms of the Department and to close down those that were run at a heavy loss and did not serve specific objectives. As a result, the income from these was gradually raised from about 28 per cent. of the expenditure in 1949 to 82 per cent. in 1955 and 36 centres including nurseries and small animal breeding centres were closed. On the other hand a few new Agricultural Stations were opened. As Editor of this journal he effected a number of changes which have greatly improved the appearance of this publication.

Dr. Joachim was elected President of the Ceylon Association for the Advancement of Science in 1942. He served as Leader of an F. A. O. Agricultural Mission to the Yemen during October-December, 1955. He was also a delegate to the Empire Conference of Soil Scientists at Rothamsted in 1930, to the Third International Congress of Soil Science at Oxford in 1935 and to the Fourth International Rice Commission in Tokyo in 1954.

His outstanding scientific experience which he has gained for over 30 years in the Department of Agriculture will not be lost to this country for soon after his retirement, Dr. Joachim was appointed by the Tea Research Board to be the Scientific Adviser of the Institute for the Low Country where he will be specially concerned with the organization of a Sub-Station for tea, and with planning an intensive research programme to be carried out on that Station for the Low Country tea growing areas of Ceylon.

ARTICLES

The Culture of Sugar Cane

E. W. H. JAYASEKERA, Research Officer, Department of Agriculture, Ceylon

INTRODUCTION

Received 8.10.56.

1. Food Value of Sugar

A balanced human diet should consist of body building foods, protective foods and foods that supply energy. The main sources of energy are sugars and starches. As an agricultural crop, the sugar cane is capable of producing more calories per acre than any other. Some idea of efficiency of sugar in this respect can be had from Table 1.

Table I—Land required by Various Crops to produce 1,000,000 Calories

Food	*Acres of Land*
Sugar	0·13
Corn	0·32
Sweet potato ..	0·36
Irish potato	0·44
Rice	0·59
Whole wheat flour ..	0·90

The figures suggest that the average individual can most profitably obtain the major fraction of his calorific requirements from sugar. Every endeavour should therefore be made to make cheap sugar available in sufficient quantity. In this country which imports its complete sugar requirements, sugar is a relatively expensive commodity. Table 2 shows the consumption of sugar per capita per annum in different countries.

Table 2—Sugar Consumption Per Capita Per Annum

Country	*Pre-war Per Capita Consumption in Pounds*
Hawaii	145
Denmark	121
England	106
Australia	112
Louisiana (U. S. A.) ..	103
Canada	101
Germany	58
Java	11
India	28
Mexico	31
Peru	31
Natal	54
Ceylon	30–40

2. Sources of Sugar

The sugar of commerce derives primarily from the processing of two crops, sugar cane and sugar beet. Sugar cane is the more important of the two. Of a total world production of sugar of 36 million tons in 1953-54, sugar beet accounted for 15,500,000 tons while sugar cane produced 20,500,000 tons.

Sugar can also be produced from various other sources such as palms sorghum, ripe fruits, &c., but it is unlikely that these sources will in the foreseeable future offer serious competition to beet and cane as producers of sugar.

The sugar beet which stores sugar in its swollen roots, is a temperate crop. The manufacture of sugar from sugar

beet is comparatively recent, the first commercial beet sugar having been manufactured on the European continent about the middle of the eighteenth century. The development of this industry was to a large extent due to a scarcity of sugar on the continent during the Napoleonic wars (1) . It is unlikely that sugar beet will replace sugar cane as a producer of sugar. Not only is the management of the beet crop more difficult, but the average yield of sugar per acre from the beet crop is 2 tons ; under proper management the cane is able to produce as much as 7 tons of sugar per acre.

Of the other sources of sugar only the potentialities of the palms merit consideration. The following palms are possible sources of sugar—(*a*) Wild date (*Phoenix sylvestris*), (*b*) Coconut (*Cocos nucifera*), (*c*) Kitul (*Caryota urens*), (*d*) Aren palm (*Arenga saccharifera*), (*e*) Palmyra (*Borassus flabellifer*), (*f*) Nipa (*Nipa fruticans*). The sugar in the sap of the last named undergoes inversion so rapidly that it is claimed to be unsuitable for sugar but is used for the production of alcohol (2).

The possibilities of developing a sugar industry by tapping palmyra and date continues to receive attention in India. The comments of Goswami (3) on the possibility of such an industry are relevent and are reproduced below in full :

" Whatever may be the possibilities of a palm gur industry, it will be idle to dream that this industry will enable any release of present acreage of land under sugar cane. In the manufacture of sugar, no plant has been able to match the wonderful grass, sugar cane, known from ancient times. The figure of 3 tons of Gur per acre from palms appears to be high and even though such tonnage is possible from the best varieties of palms and under the best conditions, it is still low compared to 3 to 7 tons of sugar per acre possible from sugar cane under appropriate conditions. As the palm is tapped the yield of sugar will decrease every year and uneconomical trees will have to be replaced to maintain a steady yield.

" The palm gur industry shall have also to overcome the difficulty of tapping tall palm trees for juice. At present it requires clever climbers to tap tall palm trees. Unless dwarf palms are produced by research, tapping palms will remain a costly operation. Another difficulty is to find out fuel needed for concentrating the palm juice. In the cane sugar industry, the concentration of the cane juice is done by means of bagasse (the fibre) produced during milling. In palm gur manufacture, this has to be done by purchased fuel which in India will be a heavy item of cost.

" The fifty million palm trees of India must be very widely scattered. In order to become a profitable industry, concentration of a great number of trees in a place is necessary. Thus to produce for example 100 tons of gur daily for about three months like a 1,000-ton capacity cane sugar factory, a minimum of 3,000 acres of land will be necessary, assuming a yield of 3 tons of gur per acre. Considerable research is necessary to develop the palm gur industry into a successful one. It can at present flourish only as a cottage industry in waste lands not suitable for other crops. While the augmentation of our sugar stocks from this source would be welcome, any idea of it becoming a successful competitor of the cane sugar industry is premature if not wild."

The sugar cane is a perennial grass which stores sugar in its long, thick above-ground stem. It is a native of the tropics and grows best under tropical conditions. As a producer of sugar, it is pre-eminent, giving up to 7 tons of sugar per acre under proper management. As the cane crop forms the best basis of a sugar industry in Ceylon, the rest of this section is devoted to a discussion of this crop, its management and performance in other areas.

THE CULTIVATION OF SUGAR CANE

1. Historical

The cane is among the oldest of cultivated plants, the first recorded mention of it occurrring among the legends concerning the Buddha about the fourth century B.C. The belief is general that the sugar cane originated in India. From India the cane is believed to have been carried East to China, probably via Assam. The Chinese then carried it to Formosa, Java and the Philippines. In the other direction, the Arabs introduced the cane to North Africa and Southern Europe. Thence Columbus carried the cane to Santa Domingo on his second voyage in 1494. From Santa Domingo it spread to North and South America, Cuba and the West Indies.

In the earliest times, sugar cane was cultivated as a garden crop, and its use restricted to chewing of the stalks and drinking of the juice. The first clear record of sugar occurs about A. D. 627 in Persia, and it is also recorded that at about this time Chinese were being sent to India to learn the art of sugar making.

With the spread of the cane, the manufacture of sugar expanded rapidly, but for a long period, techniques of both cultivation and manufacture were poor. With the application of scientific principles to cultivation practice and manufacturing methods, however, rapid advances were made from the latter part of the nineteenth century onwards. Today the sugar industry is a vast concern spread throughout the equatorial belt. Table 3 gives production figures of some of the more important cane growing countries of the world.

Table 3—Yields of Sugar and Acreages Harvested in 1953–54

Country	*Acreage Harvested 1953–54*	*Sugar Produced in Tons*	*Yield of Sugar Per Acre in Tons*
Hawaii	108,333	975,000	9·0
Peru	87,826	606,000	6·9
Indonesia	108,928	610,000	5·6
Formosa	248,064	769,000	3·1
Barbados	45,897	179,000	3·9
Australia	338,919	1,254,000	3·7
British Guiana	82,000	246,000	3·0
Puerto Rico	383,928	1,075,000	2·8
Mauritius	173,793	504,000	2·9
South Africa	223,448	648,000	2·9
Jamaica	151,250	363,000	2·4
Trinidad	75,217	173,000	2·3
Fiji	61,724	179,000	2·9
Dominican Republic	285,217	656,000	2·3
Cuba	2,406,500	4,813,000	2·0
Philippines	639,500	1,279,000	2·0
U. S. A.	331,176	563,000	1·7
Brazil	2,480,000	1,968,000	0·8
India	1,541,250	1,233,000	0·8
Pakistan	141,666	85,000	0·6

2. Principles of Sugar Cane Cultivation

Not only is the sugar cane among the oldest of the cultivated plants, but systematic investigations into the cultural requirements of the crop have been in progress for a considerable period. Sugar experiment stations were established in Indonesia and Louisiana in 1885, in Hawaii in 1895 and in Queensland, Australia, in 1900. Consequently the principles of cultivation of the crop are today clearly understood.

In commercial planting, cane is propagated vegetatively. The cane stalk consists of alternating nodes and internodes, a vegetative bud occurring at each node. For planting, the stalk is cut up into pieces (setts), each sett having a fixed number of buds. On planting the setts in the soil, these buds germinate each giving rise firstly to a single shoot (primary shoot). After the primary shoot has achieved a minimum of growth, it puts out a varying number of secondary shoots (tillers) from the base of its stem. The whole is collectively known as the clump or stool.

After tillering is over, the young shoots of the clump grow and elongate rapidly to form cane stalks. As growth comes to an end, maturation begins. In the young crop the distribution of sugar in the stalk is uneven, being quantitatively higher at the base than at the top. As maturation progresses, the sugar content in the top of the stalk increases. By maturation is meant the attainment of the same quantitative status of sugar throughout the length of the stalk. After maturation, the cane is able to hold its sugar for a variable period of time depending on various factors, chiefly varietal and environmental. Thereafter, the sugar content begins to drop ; this phenomenon (overmaturity) commences at the bottom end of the stalk.

The life of the crop therefore falls into four phases :

(i) Germination.
(ii) Tillering.
(iii) Stalk elongation.
(iv) Maturation.

(i) Germination. The aim is quick, uniform germination. Quickness is desirable because the longer the setts remain dormant in the soil, the greater the chances of damage. Uniform germination is of the greatest importance. Not only does it allow of all subsequent operations being timed to a nicety, and results in uniform final stands and better yields. The buds that emerge late from the soil seldom grow normally ; they usually struggle for 2 or 3 months and are then shaded out. There is, of course, a tendency for compensatory filling in of gaps by greater tillering of adjacent clumps, but this is not a mechanism that should be depended on. It is far more desirable to aim at a full, quick, uniform germination.

Factors that affect germination are listed below :

Soil factors

(*a*) Soil aeration.
(*b*) Soil moisture.
(*c*) Soil temperature.

Planting-material factors

(*a*) Variety.
(*b*) Nutrition status.
(*c*) Position of bud on the stalk.
(*d*) Length of cutting (number of buds per sett).
(*e*) Delay between cutting and planting.

(*f*) Depth of soil cover over the cutting.
(*g*) Pre-planting treatment of the setts.
(*h*) Position of bud at planting.
(*i*) Presence of sheath.

Soil Factors.—It is not necessary to enter into a detailed consideration of soil factors. The working of the soil to a good tilth and subsequent intelligent soil management will take care of this aspect of cultivation.

Planting-Material Factors. (*a*) *Variety.*—Great differences are possible in germination between varieties. Some varieties germinate quicker than others. In practice, however, this factor is unimportant, since there is no correlation between the initial rate of germination and final yields.

(*b*) *Nutrition Status.*—The earlier practice was to use stalks from poorly developed fields as planting material. Subsequent investigation of the problem, however, has indicated that cane grown under conditions of high nitrogen and moisture provide the best planting material. Setts from such fields not only germinate better, but tend to yield more ultimately. The best setts are those which have a high content of nitrogen, water and glucose.

(*c*) *Position of Bud on the Stalk.*—Buds at the top of the stalk (top setts) germinate better than those lower down (body and butt setts). This is primarily due to the fact that the content of nitrogen, water and glucose is higher at the top end of the stalk. Moreover, the buds of body setts are older than those of top setts.

(*d*) *Length of Cutting.*—Setts can be single-budded or the whole stalk can form a sett. The consensus of opinion favours the use of 3-budded setts rather than setts with less or more buds.

(*e*) *Delay between Cutting and Planting.*—It has been noted in Java that the germination of top cuttings improves with keeping for a few days under conditions of high temperature and low humidity. On the other hand, Hawaian experience suggests that storage of body setts has a deleterious effect on germination.

(*f*) *Pre-planting Treatment of Setts.*—Studies in various countries have shown that soaking setts in cold running water improves germination. With the spread of disease, soaking in various fungicidal solutions has been resorted to.

(*g*) *Presence of Sheath.*—The retention of the stalk leaf sheath enclosing the bud of planting material is undesirable. The sheath prevents the bud from having direct contact with the soil, and mechanically obstructs the emergence of the bud.

(*h*) *Position of Bud at Planting.*—On the stalk the buds are arranged alternately opposite. If the setts are placed in the soil with any one bud facing up then the opposite bud will be under the sett, and will take longer to emerge, and germination will therefore not be uniform. The ideal placement is to lay the setts with the buds pointing sideways so that all buds will emerge at the same time.

(*i*) *Depth of Soil Cover over Setts.*—The more soil there is over a cutting, the greater the distance the young shoot has to travel to emerge from the soil. The principle is that when conditions are optimal, the setts should be covered

lightly. Thus when planting under irrigated conditions in warm seasons, the setts are covered with as little earth as possible, except on the lighter soils which tend to dry out rapidly. Under rain-fed conditions, when planting into dry weather, the setts are placed deep ; if wet conditions are to follow planting, the setts are placed shallow.

(ii) Tillering. The tillering phase follows satisfactory and uniform germination. The ideal to be achieved is the emergence of the tillers in a single flush, since this has the advantage that all the stalks at maturity will be uniform and of the same age. At the base of the stalk, the internodes are very short, so that in effect there occurs a large number of nodes (and therefore buds) at the base of the primaries. This circumstance is most advantageous since tillering consists in the germination of these buds at the base of the primaries to give secondary shoots, and the concentration of buds at the base of the primaries, allows of the formation of many tillers.

Tillering is controlled by the following factors :—

(*a*) Variety.
(*b*) Light.
(*c*) Temperature.
(*d*) Nutrient status.
(*e*) Moisture.
(*f*) Earthing up.
(*g*) Planting time.

(*a*) *Variety.*—Some varieties tiller profusely while others are inherently tiller-shy. As a general rule this is not a problem of any consequence since commercial varieties are bred for a certain threshold value of tillering, and poor tillerers are eliminated in selection.

(*b*) *Light.*—High light intensities promote tillering. It is a well known fact that tillering is poor in cane developing in cloudy weather.

(*c*) *Temperature.*—High temperature promotes tillering.

(*d*) *Nutrient Status.*—The two chief elements that promote tillering are nitrogen and phosphorus. Increasing doses of nitrogen increase tillering up to an optimum. With phosphorus, the effect is interesting : even in soils that are not lacking in the element, its application results in an increased tillering, but the effect is temporary.

(*e*) *Moisture.*—Adequate soil moisture is of course necessary for maximum tillering.

(*f*) *Planting Time.*—Planting into a warm bright season produces better tillering than planting into cold cloudy weather.

(*g*) *Earthing up.*—The rule is that light and delayed earthing up promotes tillering, while the application of earth to the plant furrow early and in large quantities tends to inhibit tillering. With the former practice, the bases of the primaries are well exposed to heat and light and tillering is profuse. In field practice the general rule is to keep the plant furrow open until tillering is complete.

It will be seen that of all the factors that influence tillering, one has, under normal conditions of cultivation, operational control over only three, viz. nutrient supply, moisture control, and earthing up. Assuming that the first two are under adequate control, tillering is to a large extent dependent on the timing and nature of the earthing-up operation.

The guiding principle with this operation is to keep the plant furrow open until tillering is adequate and thereafter fill it in with a heavy earthing to inhibit further tillering. In actual practice, particularly when the setts are planted close to the surface, it is desirable to effect a very light earthing up when the primaries are about a foot high. When the primaries emerge, their basal regions tend to be exposed and this impedes tillering. The effect of this light earthing is to bring earth round the base of the primaries, thereby bringing moisture to the dormant buds and encouraging tiller formation.

The number of millable stalks that a crop can carry to maturity is under given conditions, limited and predictable. Generally, tillering is allowed to proceed till the number of stalks present exceeds the expected number of final millable stalks by a margin sufficient to make allowance for tiller deaths from various causes. At this stage, the second heavy earthing up is applied to depress further tillering.

(iii) Stalk Elongation. For ideal crops, stalk growth should proceed smoothly and rapidly toward a maximum, and decline with similar smoothness. There are three main factors affecting growth that are capable of control :

(*a*) Nutrient status.
(*b*) Moisture.
(*c*) Weed competition.

(*a*) *Nutrient Status.*—Obviously nutrients must be readily available for growth. Sugar cane is a heavy feeder, and the application of fertilizer is essential for the realisation of optimum yields. It is estimated that a 45-ton crop of cane removes 119 lb. of nitrogen, 73 lb. of phosphoric acid and 148 lb. of potash.

The application of artificial fertilizers will depend on the availability of nutrients in the soil, but the elements normally supplied are N, P & K. The need for supplementing the nutrients present in the soil with artificials is felt even on virgin land after a few years cropping.

Increasing doses of nitrogen result in higher cane yields until a limit is reached. These increased cane yields are, however, accompanied by poor juice quality, unless the higher dose of nitrogen is accompanied by a high dose of potash. Phosphates have to be added when this element is limiting growth.

Phosphate and potash are best placed in the root zone, and are therefore applied deep in the plant furrows at planting. The nitrogen is generally applied in split doses, and experimental data indicate the beneficial effect of this practice provided the entire fertilizer is applied in the first three months after planting.

In some areas the need for the application of trace elements has been established.

Soils that are acid must be dressed with lime during land preparation.

The use of farm yard manure has much to recommend it ; its use was common when animals were the major source of power on the farm. The advent of the machine has, however, reduced availability of farm yard manure, and its use in mechanised areas is comparatively unknown today.

(*b*) *Moisture.*—Lack of moisture or excess of it can cause a

check in growth. Deficiency can be corrected only where supplementary irrigation is available. Excess moisture during heavy monsoon rains has to be drained out.

(c) *Weed competition.*—This is an obvious point. Actual methods are discussed later.

(iv) Maturation. As growth comes to an end, maturation begins, and at maturity there is a uniform distribution of sugar in the stalk.

There is very little that can be done to hasten maturity. A dry period is advantageous at this time, and in practice the withholding of irrigation water is the main consideration.

3. Practice of Cane Cultivation

(i) Land Preparation. Sugar cane generally responds to deep cultivation and it is usual in preparing the land to stir the soil to a depth of 12-18". Planting is usually done in furrows. Therefore after the soil has been worked to a good tilth, furrows are made 6-10" deep.

(ii) Spacing. A narrower spacing between furrows (rows) is better than a wide one. However, as will be seen subsequently other practical considerations tend to determine the limits of spacing between rows.

(iii) Planting. Ideally 3-budded top setts are used or special planting material fields are cultivated, so that the crops on these fields are 7-8 months old when required for planting out. Such fields are of course specially cared for.

The setts are placed end on in the furrows with their eyes pointing sideways and covered over with a light layer of earth. Phosphate and potash manuring is done at the time of planting, the fertilizers being placed in the furrow a few inches away from the setts. Nitrogen is applied in split doses.

Planting is followed by a light irrigation. Thereafter water is applied as and when required. As a rule, during germination and establishment of the crop, irrigation should be light and frequent. After establishment, the irrigation is gradually made heavier and less frequent until a limit is reached. This practice encourages deep rooting and consequently conduces to lodging resistance.

As with any other crop, the control of weeds is a major consideration and various practices are adopted to achieve this end. It must be remembered, however, that with a good crop of cane (i.e., where germination and tillering have been satisfactory) attention to weed control is necessary only at the early stages. Once the crop has closed in, the ground between rows is completely shaded and weed growth will be nil.

When the primaries are about a foot high (at the 3-leaf stage) a little earth is thrown into the furrows in the form of a light earthing to cover the base of the primaries. After tillering is adequate, the furrows are closed in with a heavy second earthing, leaving a very shallow drain for irrigation. It is also customary to earth up again, normally before the onset of monsoon rain. In this operation earth is thrown up against the clumps so that the original plant furrow becomes a ridge and *vice versa*. This final earthing has the effect of propping up the stalks and so minimises lodging, and also helps in draining the fields. Thereafter, attention is paid to irrigation and drainage while the crop grows and matures.

"Rayungan" or sprouted sett used for planting

Manuring setts planted in ditches

When the cane is mature, the stalks are harvested and transported to the factory for conversion into sugar or jaggery as the case may be. In harvesting, the stalks are cut flush with the ground, the leafy tops are lopped off and the stalks cleaned free of trash before being taken away.

After harvest of the first crop of cane, it is not necessary to replant the fields. After suitable treatment, one or more further crops can be taken depending on circumstances. The first crop after planting is referred to as the plant crop and crops taken thereafter without replanting are called ratoons, first, second, third ratoon, &c., as the case may be.

The mechanics of ratoon crop development are as follows :—When the plant crop is harvested, the root stock (stubble) is left behind in the soil. The base of the stalks below ground are therefore undamaged. In ratooning the buds at the nodes of these stalk bases left in the ground germinate to give a new set of stalks.

At the end of the harvest the field is left with a large volume of trash (dead leaves and discarded leafy tops rejected at harvest). Before any ratooning operation can commence, there is the immediate problem of disposal of trash. The simplest method and one adopted in many countries is to heap the trash and burn it. This practice, however, does not meet with universal approval and in some centres the trash is moved into various positions in the field and left to decompose in *situ*. A common practice is to lay the trash in alternate inter-rows.

Thereafter three main operations have to be done. Firstly, the inter rows must be cultivated and this soil loosened to allow for easy growth of the ratoon crops roots. Secondly, some operation designed to render the upper buds of the stalks (and therefore close to the surfact) impotent, so as to encourage the buds deeper down to germinate, has to be carried out. The purpose of this operation is to encourage the development of the ratoon crop from as deep down in the soil as practicable and prevent the stool "coming to the top".

Thirdly, the ratoon crop has to be manured and under irrigated cultivation furrows must be made to carry the irrigation water into the fields. Thereafter the normal cultural operations are necessary.

These then are the general principles of sugar cane cultivation. It is now of interest to review briefly the practices existing in various countries.

4. Existing Cultivation Practices in Cane Growing Countries

(i) Australia. The bulk of the Australian cane is grown in the state of Queensland (about 4 per cent. of the total being grown in New South Wales). In Queensland, 75 per cent. of the cane is cultivated under rainfed conditions, the rainfall in the sugar belt varying between 40-180" per annum. In the other 25 per cent., irrigation supplements rainfall.

A striking feature of the Queensland sugar industry is its high degree of mechanisation. All field operations (except harvest) are mechanised. Harvesting is generally done by hand, but each year the extent harvested mechanically is increasing.

The land is prepared to a depth of about 12" and furrows for planting are 4 3/4 ft. apart.

4 Month old Cane Crop at Polonnaruwa

Mature Cane Crop ready for harvest—Polonnaruwa

The entire stalks are used as planting material. Planting is done by various implements, the cutter planter being the most advanced. This machine makes the planting furrow, cuts the cane into setts, lays them end on in the furrows, distributes fertilizer and then covers the setts with earth. The machine can plant about 4-5 acres per day. Since the major part of the crop is rainfed, the depth of soil cover varies with the conditions during planting. Some cane is also planted by hand. In this method, entire sticks are thrown into the furrow and are later cut by hand into pieces while they lie in the furrow. The setts are then covered over.

Manuring consists of applying 4-6 cwt. per acre of complete fertilizer to the plant crop while ratoons receive more than 2 cwt. of sulphate of ammonia alone. The phosphate and potash with a fraction of the nitrogen are applied at the time of planting while the bulk of the nitrogen is applied as a top dressing.

After-care of the crop is also done mechanically. A variety of implements for the control of weeds in the furrow and in the interspace are available. The use of chemicals for pre-and post-emergence weed control has proved successful and is fast becoming popular.

Earthing-up procedure is standard, namely, maintenance of the planting furrow in an open condition until tillering is adequate, and flattening out of the land thereafter.

The cane is grown as a one-year crop being harvested at the age of 12-17 months. Harvesting is mainly by hand although the extent being harvested mechanically is increasing. The standing cane is burnt prior to harvest and manual harvesting is done on contract by seasonal labour. In 1950, contract labour was paid about Rs. 5 per ton of cane harvested and loaded into waggons. The average output is 4 tons of cane per man per day.

The system of cultivation is *monoculture*, the land carrying one plant and 2 ratoon crops followed by a green manure fallow before being planted to cane again. The bulk of the cane land is owned by individual farmers who sell their cane to the factories. The factories work for 6 months from June to December.

(ii) Java. In pre-war Java, under conditions of cheap and plentiful labour, a highly efficient industry was developed. A characteristic feature of the industry was the intensive cultivation practice using manual labour. The field and the factory were under one management. The cane was grown under irrigation and the system of land tenure was such that cultivation was restricted to a plant crop only, no ratooning being generally done. The industry during this period was an impressive example of the successful application of science to industry.

As an example of their methods, below is recounted the procedure of preparation of the land for planting by what was known as the Reynoso method (4).

All operations were done by hand. No ploughing was done at all. Instead, planting furrows 3-3½ ft. apart were dug by manual labour. These furrows were 16 in. wide and 12-14 in. deep. Each furrow was 30 ft. long, there being cross drains running down the field at

30 ft. intervals. These small cross drains connected with larger field drains so that an elaborate system of drains was constructed. These drains served as irrigation channels during the dry period and effectively drained the land during the wet season. Before planting, about 4 in. of soil was thrown back into the furrows, to form a seed bed.

Generally, separate nurseries were cultivated to provide planting material. Two or three-budded setts of sprouted buds (*rayungans*) were used for planting. The fields were irrigated before planting and in the case of setts, they were pressed into the soil with the buds pointing sideways until the tops of the setts were just visible.

All subsequent operations were also done with manual labour. Manure was applied according to the needs of the soil. Actual application of manure was effected with little spoons ; holes were made by the side of each plant, the manure was dropped into these holes and the holes covered thereafter. The normal principles of earthing up were followed ; a final heavy earthing was effected before the onset of the monsoon both to prop up the plant and facilitate drainage.

Cane was harvested at the age of 14-17 months. The havesting operation consisted of digging up the clumps, so that no cane went waste.

The law did not permit the leasing of the land (which belonged to the citizenry) for more than one year at a time and therefore only a single plant crop could be grown. The system was one therefore of rotating paddy and sugar cane, the land owner growing paddy and the factory subsequently leasing it out for one year for the cane crop.

The factory crushed for 6-7 months.

(iii) Louisiana, U.S.A. The principal limiting factors in Louisiana are a high water table and cold winter.

Due to the high water table elaborate systems of drainage have to be maintained and the cane is planted on raised beds, the distance between rows being 6 ft. with a drain between each cane row. Not only is the cost of opening and maintaining these drains heavy, but the amount of land uncultivated in this system is high.

The cold winter may result in damage by frost. This means that the cane has only a very short growing period, while the factories have to deal with the cane quickly before frost damage can occur. The factories therefore have large capacities, and work for only 3-4 months in the year. All these factors contribute to comparatively low yields. The average yield of cane is 20 tons per acre with a recovery of 8 per cent. (1.6 tons of sugar per acre).

A characteristic here too is the high degree of mechanisation, harvesting and loading also being mechanised.

Planting commences in September. In planting the whole stalk is used without cutting up and during planting the stalks are placed half overlapping.

Control of weed is effected mainly by flaming and the use of chemical weedicides. Johnson grass, *Sorghum helapense*, is a particularly bad weed, and repeated ploughing and sheep grazing during the fallow are methods adopted to control it. Nitrogen is the chief fertilizer used.

A large proportion of the cane is grown by independent farmers who follow the general practice of 1 plant

crop and 2 or 3 ratoons. Some of the factories are owned by growers' co-operatives.

The factories work for 3-4 months in the year from mid October, till December-early January. Transport to the factory is mainly by road but some cane also comes by rail and water.

(iv) Florida, U. S. A. Sugar cane in Florida is grown on part of a vast area of peaty soil called the Everglades. This area is in effect reclaimed swamp and a most elaborate system of drainage has been evolved to render the land fit for cultivation. Irrigation is provided during the dry weather.

The major cane area is under unified control being owned by the factory.

Land preparation is mechanised but planting is done by hand with 3-4 budded setts which are placed so that they overlap in furrows 4-4½ ft. apart. Plant cane is harvested by hand at the age of 15 months.

The practice here is *monoculture*, the plant crop being followed by a varying number of ratoons and green manure fallow.

The factory season is about 5 months.

(v) Natal, South Africa. The bulk of the cane is grown as a rainfed crop. Due apparently to shortages of labour, cultivation operations are being progressively mechanised and attention is now being paid to mechanical harvesting.

Cane is harvested between the age of 12-24 months. There are a large number of individual farmers who supply cane to the factories.

The system is monoculture, the plant crop and a varying number of ratoons being followed by a green manure crop before being planted with cane again.

The crushing season extends for 9 months.

(vi) Hawaii. There is unified control of plantation and factory. About half the total cane area is irrigated.

Agricultural operations are completely mechanised. In preparing the land for cultivation, it is worked to a depth of 22-24 in. Furrows are spaced 5 ft. apart and planting of setts is partly mechanised and partly done by hand. Planting goes on all the year round.

Control of weed is effected by the use of chemical weedicides in conjunction with mechanised implements.

Manuring and irrigation are done on indications obtained from regular foliar analysis on a system devised by Clements, and known as the Clements Crop Log Method. Essentially this method consists of taking regularly samples of plant tissue from a particular organ at a specified point in the plant. The quantitative status of moisture and N P and K. of this sample is determined and compared with pre-determined optima. When the level of any of the constituents falls below the optimum, it is supplied to the plant. Another point of interest in regard to fertilizer practice is the development of the use of liquid ammonia which is supplied to the crop in the irrigation water and the aerial spraying of nutrients to the crop.

All cane is grown as a two year crop and harvested at the age of 18-24 months. Half the area is harvested every year. Harvesting, loading and transport in the field is mechanised. The use of heavy equipment for this purpose in the fields results in soil compaction and heavy sub-soilers are used subsequently to loosen the soil.

The system of cultivation is *monoculture*, the normal routine being plant crop followed by 4-5 ratoons.

The factories work for 10-11 months of the year. Transport of cane by rail is giving way to road haulage which is proving cheaper.

(vii) India. India has the largest acreage in the world under cane (an estimated 4-4½ million acres). This extent is widely spread and cultivation is therefore being done under a variety of conditions. Some factories own land and cultivate cane on a plantation basis, but this forms only a small fraction. The individual farmer small holder predominates there being an estimated 20 million farmers cultivating cane.

Standards of cultivation and yields are low. Generally little other than farmyard manure is used to supply nutrients to the crop. Furrows are spaced 1½-3 ft. apart although the latter is now the more common spacing. Three budded seed pieces are planted and the whole stalk is used as planting material though whenever possible top setts are preferred.

When ratooning is practised, seldom is more than one ratoon taken. The cane is grown in rotation, rice being usually the other component of the rotation, although occasionally other crops are included.

Only part of the cane is converted to sugar on a factory scale. The greater part of the crop is converted into jaggery (gur) in open pans on a cottage industry basis. Annually about one million tons of sugar are produced and 3 million tons of jaggery.

Factories crush for 6 months from December to May.

(viii) Formosa. The main purpose of including Formosa in this review is because of an interesting cultural practice obtaining in that country. Cane is rotated with rice and the sequence of operations is as follows :—(5)

In July, the rice is transplanted in rows 10-12 in. apart and every fifth row is left blank. When the rice is in the heading stage, cane is planted in the blank rows. After the cane is planted, no irrigation water is let in. After harvest of the rice the cane is treated in the usual manner. Early growth of the cane is somewhat poor due to lack of light and excessive moisture, but final yields are said to compare favourably with yields of cane under *monoculture*.

5. Discussion of Cultural Methods in Various Countries

(i) Land Preparation. In whatever country and whatever system, the aim of land preparation is the same, viz. that of preparing a favourable seed bed for planting. It is only the means adopted to achieve this end that varies. This variation is conditioned by immutable internal factors such as availability and cost of labour, conditions of cultivation, etc. Thus in pre-war Java with its plentiful cheap labour, preparation of the land and, in fact, all cultural operations were done entirely by manual labour. In India where the size of the individual holdings is very small similar conditions obtain. On the other hand in countries like Australia, Hawaii and Louisiana where cheap labour is non existent, machine drawn implements are universal.

(ii) Spacing. The narrow spacing has many advantages : (*a*) As a result of the quicker closing in of the crop, fewer cultivations are required, (*b*) losses

due to irregular germination are minimised, (*c*) the development of late suckers is reduced, (*d*) more efficient conservation of the soil is ensured.

The actual spacings used, however, show a wide variation. The narrower spacings are restricted to those areas where manual labour is used. Thus, in India, the spacing ranges from 1½-3 ft., in Java from 3-3½ ft. and in Egypt 2½-3 ft. Countries committed to mechanised cultivation, however, have been compelled to use wider spacings. Thus, in Australia and Florida, spacings of 4-5 ft. are used, in Hawaii 5 ft., while in Louisiana, the particular conditions of cultivation make a spacing of 6 ft. necessary.

(iii) Planting Material and Planting. While top cuttings are the best planting material, they are available for planting only when the harvesting season coincides with the planting season. In that event, the tops (which in any case are poor from the milling point of view) can be used for planting while the rest of the stalk goes to the factory for crushing. When there is no coincidence between the harvesting and planting seasons the easiest practice is to use the whole stalks for planting. In such an event the advisable practice is to plant the top and body setts in separate blocks since their rates of germination are different.

There are, however, two means of circumventing the difficulty viz.:

(*a*) By the use of *rayungans*.

(*b*) By planting nurseries, so that they are 7-8 months old when required for field planting. At this age most of the stalk provides good planting material.

The use of setts with a definite number of buds and the precise placement of them in the soil is only possible when planting is done by hand. With mechanical planting, only approximation is possible on these two points.

The number of buds per sett varies from one to the use of the whole stalk for planting. One-budded *rayungans* and two-budded setts are used in Indonesia, three-budded setts in India, while in Louisiana the whole uncut stalk is planted.

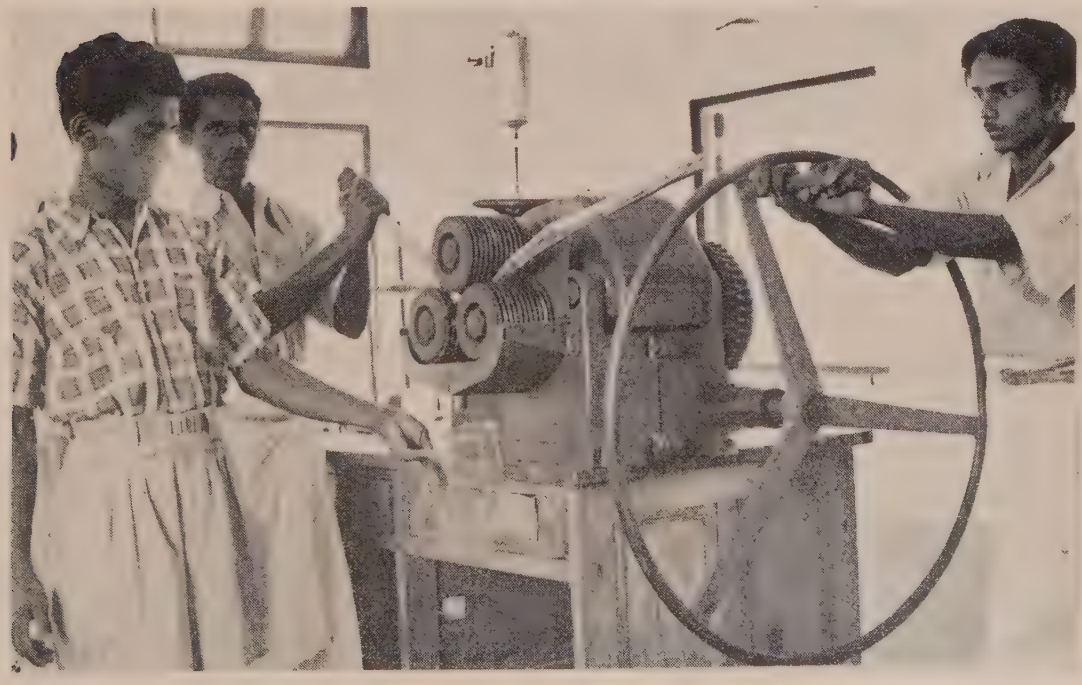
(iv) After Cultivation. The purpose of after cultivation is two-fold, viz. to control weed growth and to accomplish the earthing up operation in correct sequence.

The operations themselves are clearly defined and any variation is in the manner of performance. With manual labour various types of hand hoes are used, while in mechanised areas a variety of tractor drawn implements are available.

In recent years the use of chemicals for the control of weeds has met with great success and in Hawaii, Louisiana, Australia and South Africa at least has become standard practice. Both pre and post emergence sprays have proved satisfactory and the chemical most commonly used is 2-4D.

(v) Harvesting. The harvesting and crushing season is controlled by climate and maturity of the cane. Ideally the crushing period should coincide with the dry season and all crushing should be done at the peak of maturity of the cane. This latter condition cannot always be achieved.

Harvesting and transporting Cane at the Sugar Cane Station—Polonnaruwa



Hand operated Cane Crusher at the Sugar Laboratory—Polonnaruwa

In practice, cane is harvested at ages varying between 10 and 24 months, but most commonly it is harvested at 14–18 months.

Early harvest is undesirable as it means harvest of immature cane. It is resorted to only through necessity. Thus, in Louisiana, the danger of frost damage compels early harvest.

In South Africa, some cane is harvested at 18–24 months while in Hawaii, all cane harvested is that age.

The mechanics of the 24-month crop is of sufficient interest to merit discussion because the cane is normally an annual: yet here it is being harvested biennially. In the South African context at least, the philosophy of the two-year crop appears to have evolved out of the cultivation of cane under rainfed conditions on marginal land where water was the limiting factor to economic yields. Here, at the end of one wet season the cane tends to maturity. The quality of the juice (sucrose per cent. cane) is good. But the yield of cane itself is low so that the yield of sugar per acre is low. The cane is therefore allowed to grow through another wet season. At the end of the first wet season cane growth is checked and the crop tends to "maturity": with the advent of the second wet season growth commences again and more cane is formed. At the end of the second wet season sugar accumulation takes place again. Then not only is the quality of the juice satisfactory, but so also the yield of cane. Harvest at that time is economical.

Under Hawaiian conditions this philosophy appears to have proceeded a step further. Whereas in South Africa rainfed cane is allowed to stand through two wet seasons, in Hawaii the crop is kept growing throughout the 24 months of its life by irrigation where available.

One of the fundamental factors to be considered when comparing the 12–16 month crop with the 18–24 month crop is the yield of sugar per unit of time. In other words will a 24 month crop yield approximately twice as much as a 12 month crop ? It is claimed that this is so.

(vi) Ratooning. About 75 per cent. of the world's cane harvest in any year is ratoon cane and it is a truism that the ratoon crop is the money crop. The reason for this is of course that a number of operations required for planting cane are eliminated in ratooning. Ratoon cane shows a tendency towards a progressive decline in yield with each successive ratoon. With proper management, however, this effect can be minimised for the first few ratoon crops. The reason for this decline can be attributed firstly to the fact that with every ratoon the crop tends to come to the surface, secondly the soil tends to become progressively root bound. Thirdly, soil compaction takes place and fourthly, poor ratoon yields are often due to neglect on the part of the farmer. Coming to the surface can be delayed by planting deep initially and forcing the ratoons deep by correct practic. Correct intercultivation and judicious manuring, will combat the other disadvantages.

Pre-war Java did not generally ratoon cane. This was due not to any technical objections but the law of the land. All land blonged to the citizency

and by law this land could not be leased (by the sugar companies in this case) for more than one year at a time.

While no ratoons are taken in the North of India, one ratoon is normal in the South. Australia takes 2 ratoons, Hawaii 4–5, British West Indies 6–7, Cuba 6–10, Florida 4–5, Mauritius 6-7 and Puerto Rico 5. The actual number of times the crop is ratooned is a matter of economics.

(vii) Use of Fertilizer. The use of artificial fertilizer in sugar cane cultivation is general. Variation is seen in the quantities, ratios and composition of fertilizer but N P and K are the elements usually supplied.

Nitrogen is most commonly applied as sulphate of ammonia, and it is most commonly applied in split doses. Phosphate is mostly applied as superphosphate, the fertilizer being placed deep in the root zone in the plant furrow at planting. The two most commonly used sources of potash are the muriate and the sulphate. It is applied in the plant furrow at planting.

The need for trace elements has been demonstrated in at least two centres. On the peat soils of Florida the use of dressings of copper, zinc and manganese is normal practice while in Australia responses to dressings of copper have been demonstrated in localised extents.

MANUFACTURE

1. Historical

When the cane has grown to maturity it has to be harvested and processed. Broadly stated, the process of manufacture consists firstly of extracting the juice from the cane. This juice is in effect a dilute solution of sucrose (sugar) together with impurities. As much as possible of the impurities are removed by various treatments. Thereafter the juice is concentrated by boiling until sugar crystallises out.

In the early days of sugar cane cultivation, each farmer was his own miller, processing the cane he grew himself. The juice was expressed by passing the stalks through 3 roller mills. Initially these rollers were made of wood and rotated by hand. They were so poor in performance that the cane was passed through several times to effect an adequate extraction. Metal rollers were later introduced and bullocks took the place of manual labour for rotation of the mills. Today these mills are power driven.

The expressed juice was led into metal pots (open pans) and heated. During the heating the impurities coagulated to form a surface scum and were ladled out. When the juice boiled down to a thick syrup, it was unloaded and stood for periods varying from 10 to 30 days. At the end of this period a layer of sugar crystals was formed at the bottom of the container.

These early methods were crude and the recovery of sugar per cent. cane was poor. Due, however, to the high prices the commodity fetched in these early days the industry persisted. With the passage of time, inevitably prices fell and the need for improvement was felt.

There were obviously two points at which improvement could be effected. Firstly, to increase the extraction of juice (sugar) from the cane and secondly to increase the recovery of sugar from this juice by more definite and tangible control of crystallisation

and reduction of losses in waste products.

Improvement of juice extraction was simple and was brought about by improvement of the type of roller, the number of times the bagasse (fibre) was passed through and cutting of the cane into little pieces (as a pre-treatment) before passing into the mills. In modern practice the cane passes through a series of pre-treating shredders and knives and a 2 roll crusher before being sent through a set of 3–7 three roll mills for juice extraction.

Boiling juice in open pans did not allow of adequate control of crystallisation, and increase of recovery of sugar from the juice only became possible with the introduction of the vacuum pan (boiling under reduced pressure) into sugar boiling about the middle of the nineteenth century. This inovation marked the birth of the modern era of the sugar industry. With the introduction of the vacuum pan and the application of scientific principles, the stage was passed when it was necessary to boil juice in open pans and stand syrup for long periods until some sugar was formed. It now became possible to control each stage of the process analytically so that maximum output was possible.

The introduction of these far-reaching improvements however, had one other major effect on the industry. The capital outlay for the installation of a vacuum pan factory was so high and the technical control so complex that the period when each farmer milled his own cane automatically came to an end. The centralised factory manufacturing sugar from cane grown in its proximity came into being.

2. System of Manufacture.

There are then two methods of processing cane.

(i) The open pan system.

(ii) The vacuum pan system.

The open pan system can be used to manufacture one of two products, viz. (*a*) Jaggery (Gur of India) or (*b*) Khandsari sugar.

The vacuum pan system allows of the manufacture of two products, viz. (*a*) Brown sugar (later converted into refined white sugar if desired) and (*b*) Plantation or mill white sugar.

(i) The Open Pan System. The open pan system is the prototype of the modern vacuum pan factory. It is very simple in operation and much less efficient than the vacuum pan factory.

Today, the use of the open pan for manufacture is very limited. Its greatest development is found in India where numerous factors have contributed towards its perpetuation. While at the present time a great deal of research is being carried out to improve techniques and yields in the open pan in India, the tendency is towards the encouragement of vacuum pan factory establishment. In most other countries the open pan system no longer exists.

Products of the Open Pan. (*a*) *Jaggery* (gur). Juice is extracted by passing through a single 3 roll mill (there are some new designs of mill where the cane is crushed twice). These mills may be power driven or operated by bullocks. There is no pre-treatment of the cane for milling.

The extracted juice is boiled in open pans. Lime (or a variety of other substances such as extracts of bundakka

stalk, etc.) is used during clarification. On boiling, impurities form a surface scum and are ladled out.

This clarified juice is now boiled to a temperature of 116–120° C. On cooling, the syrup sets into a solid mass (jaggery).

The production of jaggery is a major cottage industry in India. It is estimated that in 1948-49 jaggery production was 3 million tons as against 1 million tons of sugar. A great deal has been said about jaggery for and against it. There is a belief that it is more nutritive than sugar, that it is sweeter and more easily digestible than sugar. That it is more nutritive than sugar has not been established and it is unlikely that it is either sweeter or more easily digestible than sugar. It is a fact, however, that there is more sugar per unit of weight in sugar than in jaggery. If at all, the impurities in jaggery may provide nutritive elements. Jaggery making is wasteful, in that less sugar is extracted from the cane in jaggery making than is done in modern sugar factories. It cannot, however, be denied that the manufacture of jaggery can be a most useful cottage industry.

(*b*) *Khandsari Sugar.* The product here is a fine grain sugar. This process is an attempt to improve the open pan system by introducing some of the modern factory features in the sense that the juice extraction and boiling is on the classical open pan pattern but in addition there is introduced in the first place the manufacture of sugar as the end product: filter presses for juice clarification, crystallisers for improved exhaustion, centrifugal separation of the sugar, and exhaustion of the syrup three times.

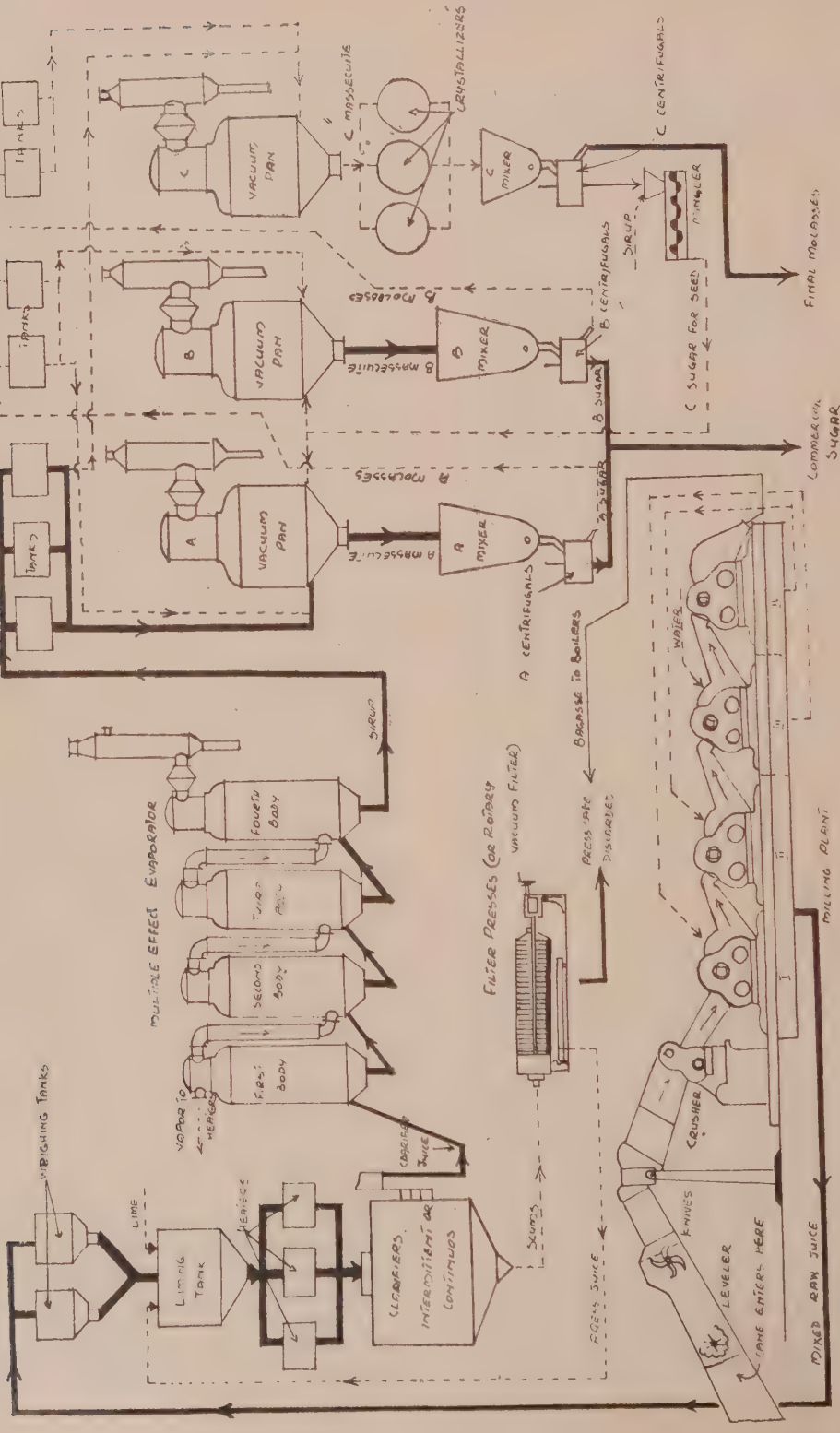
In detail, the juice is extracted by a single or two 3-roller mills and limed (if sulphuration is introduced the end product is white sugar) and heated. It is then passed through the filter presses for removal of the filter press mud, the clarified juice is back in the open pans and now boiled to a temperature of between 108--111° C and passed into crystallisers where it remains for 1 week. At the end of this period, the sugar is separated in the centrifugals. The resulting molasses is boiled again and now stored for about 3 weeks before separation of the second crop of sugar. This (molasses) is boiled again and this time it is stored for 3–4 months before going into the centrifugals.

In regard to Khandsari sugar the report of the Indian Panel on Sugar Alcohol and Food Yeast Industries published in 1947 is interesting.

"Accurate statistics regarding the production of Khandsari sugar are not available, but its production during recent years may be fairly assumed to be 75,000 tons. Khandsari is a wasteful process of producing sugar and the quality of the product is generally inferior. *It is a relic of the past.* There can be no place for it in any system of planned production. Special consideration was given in the past to Khandsari on the grounds of its being an useful cottage industry. It is not a strong argument, however, as every grower has the alternative of converting his cane into gur."

Further comment about Khandsari sugar is found in the Indian Sugar Industry Annual for 1949 which says about this process:

"It is well known that Khandsari is a far less economic method of production of sugar as compared with factories, due to the smaller recovery (of sugar) per cent. (cane), the recovery being only 5½ per cent. as compared with 9½–10 per cent. in factories. In spite of this if the production of Khandsari



FLOW DIAGRAM OF RAW SUGAR FACTORY.

sugar has been maintained at this level for the past few years, it has been due to the high price fetched for Khandsari sugar in the absence of any control thereon particularly under the prevailing shortage of sugar in the country."

Products of the Vacuum Pan. (*a*) *Brown sugar.* Most commonly the vacuum pan factory produces brown sugar which is later refined, the refinery being either attached to the factory as an integral unit or being situated elsewhere as a separate unit. There are 5 stages in processing in a vacuum pan factory.

i. Juice (sugar) extraction.
ii. Juice Clarification.
iii. Juice evaporation (concentration).
iv. Sugar crystallisation.
v. Sugar separation.

(i) The juice is extracted from the cane by passing the stalks through a series of 3-roller mills. In modern practice, before passing through the mills, the cane is first prepared for milling by passing it through shredders and knives rotating at high speed. This has the effect of cutting the cane into small pieces. Thereafter the shredded mass passes through a 2 roll crusher, and thence the mat of bagasse (fibre) passes into a series of 3 roll mills. The exact number of mills varies but generally 3-7 sets are worked in tandem. During the passage of the bagasse through the mills various forms of inhibition (addition of water to the bagasse) are used to extract as much of the juice as possible. In modern factories 90–97 per cent. of the sucrose in the cane is extracted.

(ii) The juice so extracted is a deep dirty green colour, acid in reaction, and contains numerous impurities.

The juice is first screened. To prevent the inversion that would result by heating the acid testing juice it is treated with lime until it has a PH reaction 7 or slightly more and then heated. This treatment has the effect of causing flocculation of many of the impurities. The hot juice is passed into various types of subsiders from which the precipitates can be removed as a mud. The result is a clear golden brown juice.

The mud is passed through various types of filter presses to extract as much of the juice from the mud as possible and the mud (filter press mud) is a waste product.

(iii) After clarification, there is left a clear golden brown juice which, from the point of view of the process, is a dilute solution of sucrose. The function of the evaporating phase is simply the application of heat to concentrate this juice. Evaporation is carried on till a syrup with a brix of 60--70 ° results.

(iv) Sugar production takes place in the vacuum pans. The syrup of 60–70° brix is taken into the vacuum pans for further concentration. To simplify the process the syrup is here concentrated until it becomes supersaturated and sugar crystallises out. In actual fact the process is somewhat more complicated. In the first place, the modern tendency is to discourage crystallisation in the vacuum pan but rather to seed them and grow the seed. Also various systems of vacuum pan boiling are practiced, their main purpose being to extract (exhaust) as much sugar from the syrup as possible. A common practice is what is known as the 3 boiling system. Here the syrup is boiled 3 times. The sugar from the first two boilings (A and B sugars or massecuite) is sold while the sugar from the third boiling (the C sugar) is used as seed for the first two boilings.

(v) The liquor unloaded from the vacuum pan (called masecuite) is a mixture of sugar crystals and syrup. The massecuite from the A and B boilings is passed immediately to the centrifugals where the sugar is separated from the syrup (molasses). The centrifugal is simply a cylindrical basket whose sides are lined with fine mesh gauze, rotating at high speed. When poured into it the massecuite is thrown forcibly against the sides of the fugal. The sugar is held by the gauze and the molasses expelled.

The massecuite from the last boiling (the C massecuite) is however not separated immediately. It is allowed to stand for a varying amount of time (generally 16-48 hours) before separation, the purpose being to extract as much sugar as possible from the mother liquor. After this separation the molasses (final molasses) is considered spent and forms a waste product of the industry.

The product is Brown Sugar which may be refined to give refined white sugar.

(*b*) *Plantation White Sugar by Carbonitation and Sulphitation.* These two processes are techniques developed for the production of white sugar directly without the intermediate brown sugar stage. Stated very simply, in this process the juice is limed to a definite *p*H and thereafter treated with carbon dioxide to remove alkalinity. This clarified juice on boiling gives a white sugar.

In the sulphitation process, the juice before or after liming is treated with sulphur dioxide until it is slightly acid.

The production of direct plantation white sugar is limited. The more common practice being to make brown sugar and refine it subsequently.

The quality of plantation white sugar is lower than that of refined white sugar.

Acknowledgments

I am deeply indebted to Dr. M. F. Chandraratne for very valuable criticism.

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Analysis of the Sequence of Flowerin in Rice

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Much emphasis is placed on the tillering capacity of rice varieties as the number of panicle-bearing tillers is a yield component. Katayama (1931) observed that as the tillering locus ascends, the length and weight of the panicle decrease rather regularly. Sarvayya (1932) showed that there was a significant negative correlation between the yield per tiller and the number of tillers per plant. Ramiah and Narasimham (1936) found that the main culm made the most marked contribution to yield. The removal of the 2nd and 3rd tillers did not strikingly depress yield. Kanda and Kakizaki (1953) demonstrated an inverse relation between tiller number and both panicle weight and grain number per panicle. Iso (1946) showed that within varieties the correlation coefficients were clearly negative for the relation between the number of tillers and panicle attributes such as panicle length and weight, grain number per panicle and grains per unit length. Narasingha Rao (1937) reported that the number of tillers bore a very high positive correlation with yield, followed by the number of grains per panicle and the length of panicle. He claimed that prolific tillering can reduce panicle length and the number of grains per panicle, and that it is not possible to increase the tillering indefinitely without depressing the yield.

Flowering Sequence and Panicle Characters

This paper presents an analysis of the contribution made by successive tillers to yield. The strikingly high correlation between flowering order and tillering order permits the use of the former as an estimate of the latter.

A pure-breeding material of the variety *Panniti* was transplanted in rows at a uniform spacing of 7 by 7 inches at Peradeniya. In the 50 plants of the middle row of a 3-row plot the emergence of panicles of each individual plant was recorded. The measurements of fifteen random individuals were used for calculating the correlation coefficients of the following characters with the sequence of flowering :—

Length of panicle
Weight of panicle
Number of grains per panicle
100-grain weight

The frequency distribution of the correlation coefficients are given in Table 1.

TABLE 1—Correlation of Flowering Sequence of Tiller with Panicle Attributes

Class Intervals of r	Length of Panicle						Weight of Panicle						No. of grains per Panicle						100—grain weight					
	Tiller No. in class						Tiller No. in class						Tiller No. in class						Tiller No. in class					
	∠6	6	7	8	⊿8	Total	∠6	6	7	8	⊿8	Total	∠6	6	7	8	⊿8	Total	∠6	6	7	8	⊿8	Total
+ 0·99 to + 0·90 ..																								
+ 0·89 to + 0·80 ..																								
+ 0·79 to + 0·70 ..																								
+ 0·69 to + 0·60 ..																								
+ 0·59 to + 0·50 ..																			2					2
+ 0·49 to + 0·40 ..																								
+ 0·39 to + 0·30 ..																								
+ 0·29 to + 0·20 ..																								
+ 0·19 to + 0·10 ..	1					1																		
+ 0·09 to 0·00 ..																								
0·00 to − 0·09 ..																			1		1		1	3
− 0·10 to − 0·19 ..																					1			1
− 0·20 to − 0·29 ..																								
− 0·30 to − 0·39 ..							1					1	2					2		1	1			2
− 0·40 to − 0·49 ..							2					2	1					1		1				1
− 0·50 to − 0·59 ..					1	1	1	1				2		1				1						
− 0·60 to − 0·69 ..	1	1	1			3					1*	1					1*	1	1			1		2
− 0·70 to − 0·79 ..	2					2													1			1*		2
− 0·80 to − 0·89 ..	1	1*		1*		3		2*		1*		3	1		2*	1*		4	1					1
− 0·90 to − 0·99 ..	1	1	2*	1*		5	3	1*	1*	1*		6	3*	1*	1*	1*		6	1*					1

* Significant at 5 per cent. point.

A negative correlation clearly exists between panicle order and the length, weight and number of grains per panicle and the 100-grain weight. The correlation coefficients are of considerable magnitude except in the instance of the 100-grain weight. Significance at 5 per cent. point was indicated particularly at the higher tiller numbers. In the instance of the 100-grain weight the correlation is not only low but reaches significance only in two instances.

Correlation of Flowering Sequence with Panicle Weight

The relation of flowering sequence to panicle weight was the subject of more detailed study on account of its importance in determining yield. For the purpose of this study a larger number of random individuals were used from the original material and the data grouped into classes with plants having the same number of tillers. The figures arranged in correlation tables are given in Table 2.

TABLE 2.—Correlation Tables of Panicle Weight and Flowering Order

5—Tiller Class

Flowering order x	*Panicle weight gm. y* 1	2	3	4	5	6	*Row frequency*	*Total weight*	*Mean weight*
1	1		2	3	1		7	24	3·4
2			1	5	1		7	28	4·0
3	1	2	2	2			7	19	2·7
4		3	1	3			7	21	3·0
5	2	2	3				7	15	2·1
Column frequency	4	7	9	13	2		35	—	—

6—Tiller Class

Flowering order x	*Panicle weight gm. y* 1	2	3	4	5	6	*Row frequency*	*Total weight*	*Mean weight*
1				2		1	3	14	4·7
2			1	1		1	3	13	4·3
3			3				3	9	3·0
4			2		1		3	11	3·7
5		1	1	1			3	9	3·0
6		2		1			3	8	2·7
Column frequency	3	7	5	1	2		18	—	—

7—Tiller Class

Flowering order x	*Panicle weight gm. y*						*Row frequency*	*Total weight*	*Mean weight*
	1	*2*	*3*	*4*	*5*	*6*			
1			2	3	1		6	23	3·8
2			1	5			6	23	3·8
3			2	3	1		6	23	3·8
4	1	1	3	1			6	16	2·7
5	2	1	2	1			6	14	2·3
6	1	2	3				6	14	2·3
7	3	2	1				6	10	1·7
Column frequency	7	6	14	13	2		42	—	—

8—Tiller Class

Flowering order x	*Panicle weight gm. y*						*Row frequency*	*Total weight*	*Mean weight*
	1	*2*	*3*	*4*	*5*	*6*			
1				4	1		5	21	4·2
2				3	1	1	5	23	4·6
3			1	3	1		5	20	4·0
4		2	1	2			5	15	3·0
5		2	3				5	13	2·6
6		1	4				5	14	2·8
7		4	1				5	11	2·2
8	2	3					5	8	1·6
Column frequency	2	12	10	12	3	1	40	—	—

9—Tiller Class

Flowering order x	*Panicle weight gm. y*						*Row frequency*	*Total weight*	*Mean weight*
	1	*2*	*3*	*4*	*5*	*6*			
1					3		3	15	5·0
2		2				1	3	10	3·3
3				1	2		3	14	4·7
4				2	1		3	13	4·3
5			1	2			3	11	3·7
6		1	2				3	8	2·7
7			1	2			3	11	3·7
8		2			1		3	9	3·0
9	1	1	1				3	6	2·0
Column frequency	1	6	5	7	7	1	27	—	—

10—Tiller Class

Flowering order x	*Panicle weight gm. y*						*Row frequency*	*Total weight*	*Mean weight*
	1	*2*	*3*	*4*	*5*	*6*			
1				1	1		2	9	4·5
2				2			2	8	4·0
3				1	1		2	9	4·5
4				2			2	8	4·0
5				2			2	8	4·0
6			2				2	6	3·0
7		1		1			2	6	3·0
8	1	1					2	3	1·5
9		2					2	4	2·0
10	1	1					2	3	1·5
Column frequency	2	5	2	9	2		20	—	—

The regression coefficients of the mean weight of panicles and the order of flowering are given in Table 3 and the regression lines fitted to the data are shown in Figure 1.

TABLE 3—Regression Coefficients of the Mean Weight of Panicles and the Order of Flowering

Tiller class	*b*
5	— 0·4
6	— 0·4
7	— 0·4
8	— 0·4
9	— 0·3
10	— 0·3

The results presented above indicate that the contribution of a panicle to yield declines with the lateness of its development. The regression coefficients are −0.4 for plants with 5–8 tillers and −0.3 for plants with 9–10 tillers.

The plants belonging to the 10-tiller class were analysed further by dissecting the tillering zone, for determining the loci and the system of tillering. The mean weights of panicles in the sequence of the flowering and the tillering order are given in Table 4. In column 5 of this Table is given, as a percentage of the total weight, the contribution made both by the main and the 1st-order tillers and the 2nd-order tillers. As a supplement to these results similar figures corresponding to a first generation hybrid and a variety, *Djalen"* in which 11 individuals were used, are given in columns 6 and 7.

TABLE 4—Mean Weights of Panicles in the Sequence of Flowering and Tillering order

10—Tiller Class

Flowering order (1)	*Tillering order* (2)	*Mean Wt. gm.* (3)	*Percent. of total Wt.* (4)	*F 1* Percentage contribution (5)	(6)	*Djalen* (7)
Main panicle ..	Main culm ..	4·4 ..	14·2			
2nd ,, ..	1st-order ..	3·7 ..	11·9			
3rd ,, ..	,, ..	4·2 ..	13·5			
4th ,, ..	,, ..	4·1 ..	13·3	84·5 ..	68·6 ..	78·3
5th ,, ..	,, ..	3·9 ..	12·6			
6th ,, ..	,, ..	3·1 ..	10·0			
7th ,, ..	,, ..	2·8 ..	9·0			
8th ,, ..	2nd-order ..	1·7 ..	5·5			
9th ,, ..	,, ..	1·6 ..	5·2	15·5 ..	25·5 ..	21·7
10th ,, ..	,, ..	1·5 ..	4·8			
	3rd-order ..	— ..	— ..	— ..	5·9 ..	—

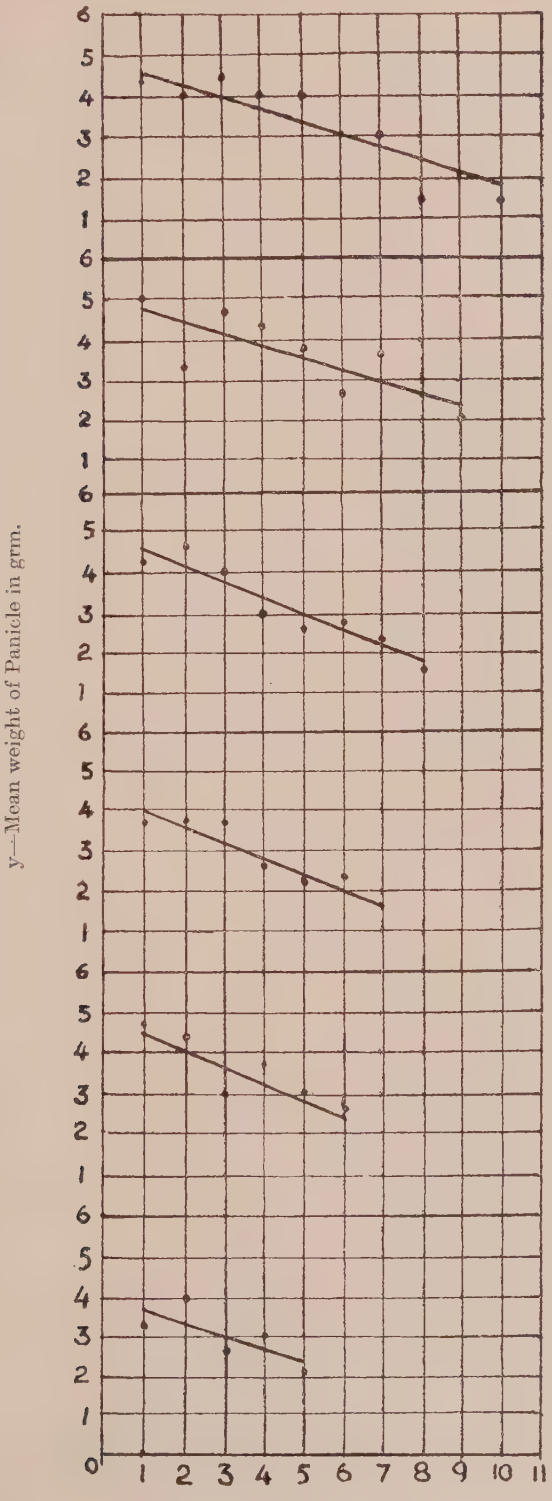
y—Mean weight of Panicle in grm.
X—Order of flowering
10—Tiller Class
y = — 0·3x + 4·9
9—Tiller Class
y = — 0·3x + 5·1
8—Tiller Class
y = — 0·4x + 4·9
7—Tiller Class
y = — 0·4x + 4·5
6—Tiller Class
y = — 0·4x + 4·9
5—Tiller Class
y = — 0·4x + 4·2

Fig. I—Regression Graphs of the different Tiller Classes

These figures show that it is the main culm and the 1st-order tillers that contribute mostly towards grain yield. The sudden drop in the panicle weight of the 2nd-order tillers is striking.

Discussion

In the investigations reported herein, the contributions made to yield by sequence of tillers on a rice plant have been assessed : The main culm and the 1st-order tillers account for 69 to 85 per cent. of the yield of a plant. Cultural practices that promote the development of 2nd-order tillers would not conspicuously raise yields. It should be the breeder's objective to select strains in which the bulk of the tillers are of the 1st-order, and agronomic practices should aim at the elimination of higher-order tillers. The value of close planting in instances of certain varieties and conditions is evident.

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Agricultural Education below the Degree Level in the United States of America

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Introduction

The importance of agriculture in the total economy of Ceylon cannot be over-emphasised, and if this important aspect of the economy is to prove successful under modern conditions, the farmer must be in a position to keep abreast of the findings of agricultural research and the developments of technology. Agricultural education, in its broadest sense, is the weapon which gives the farmer this much needed ability, and a carefully planned system of agricultural education, adapted to the needs of the country and the desires of the farming population, is of the greatest importance. At the present time, agricultural education in Ceylon is undergoing a process of reorganisation, and this paper, which is a summary of a more detailed report of a study tour in the United States, during which the writer had the opportunity of observing a cross-section of agricultural schools, colleges and universities, and of studying the organisation of agricultural education and the techniques of teaching agriculture, is published at the suggestion of the Director of Agriculture, in the hope that it will stimulate the thinking of people interested in the subject.

Non-vocational Agricultural Education

Agricultural education in the United States could be divided into vocational and non-vocational. In some educational institutions a non-vocational type of agriculture was being taught as a part of the general education given to all youth irrespective of the vocation they were going to follow later in life. Such courses were sometimes referred to as "general agriculture", "agricultural arts" or "pre-vocational agriculture", depending on the particular purpose for which a school emphasised this type of programme. Thus, as "general agriculture" the programme could be used to make students generally aware of the importance of agriculture to the community, and as "agricultural arts" to teach youth in terms of their environment and so give an agricultural bias to general education, while as "pre-vocational agriculture" the guidance value of the subject could be emphasised to determine a student's interest or lack of it

in the vocation of agriculture. It was apparent that such non-vocational agricultural education could be of fundamental importance to vocational agricultural education, since the latter had to assume that a student's choice of vocation was based on an intelligent decision.

Vocational Agricultural Education

On the other hand, vocational agricultural education was intended and designed to fit the student for efficient employment in agriculture. As the U.S. Office of Education defines it—" vocational education has reference to training for useful employment and may be given to boys and girls, who having selected a vocation, desire preparation for entering it as trained workers ; to youth who, having already entered employment, seek greater efficiency in that employment ; and to adult workers established in their occupation, who wish through increase in their efficiency and wage earning capacity, to advance to positions of responsibility ". By Acts of Congress the Federal Government not only encouraged States to provide such vocational education by a system of Federal reimbursement, but also laid down the broad outlines which such an education should follow. Thus, vocational education in agriculture was designed to meet the needs of persons over 14 years of age who had entered upon or who were preparing to enter upon the work of the farm, was to include at least six months of supervised practice in agriculture on either a school farm or other farm, and was intended to establish young men in farming and follow their progress upward in the farming ladder. It will thus be seen that vocational education in agriculture is interpreted as a continuous programme, sufficiently broad as to include the education of youth just over 14 years of age in high school, more mature youth in junior colleges, young men just establishing themselves in farming and adults who may even be prosperous farmers. Although agricultural education at the university level is also vocational, universities and colleges were excluded from federal reimbursement because of a clause which specified that federally reimbursed vocational education had to be of less than college or university grade.

Vocational Agricultural Education in High Schools

There were two types of vocational agriculture programmes in high schools : " all-day " classes, organised as integral parts of the secondary school system, and " day-unit " classes, designed for schools where an all day programme could not be provided. All courses invariably consisted of three phases : class-room instruction, farm shop-work, both conducted in the school building itself, and supervised farming programmes carried on in the field, all three phases being very closely corelated and integrated to form one

course. Class-room instruction and farm shop usually totalled about a quarter of the time of any student who chose to do vocational agriculture as a subject, and most high schools offered four years of vocational agriculture in grades 9 to 12.

With the idea of obtaining a close integration between class-room instruction, farm shop work and the actual progress of the student in his own supervised farming programme, most schools conducted their courses on a "cross-sectional" plan, where animal and crop enterprises were included in the course each year, and current problems of farm mechanics and farm management were taken up each year as they occurred in the student's farming programme. Such a cross-sectional plan had the added advantages of flexibility in meeting the interests and needs of students in solving problems as they arose in the supervised farming programmes, of providing for a distribution of subject matter material in relation to the educational attainment levels of students as they acquired skill and information from year to year, and of providing for an organisation of functional activities similar to the "farm-as-a-whole" approach of the farmer.

Farm shop work stood for what in Ceylon is called "farm mechanics" or "agricultural engineering", and formed one of the important phases of the programme of vocational agriculture. This phase of the programme was given a very natural emphasis since the use of various forms of mechanical and electrical power is increasing rapidly in American agriculture, and it is becoming increasingly necessary for farmers to do much of the repair and maintenance work on their own machinery themselves. The objective of farm mechanics instruction is to train individuals to do the unspecialised mechanical jobs that need to be done on the farm and in the house with the tools a progressive farmer has accessible. Thus, the equipment used in teaching depended on the mechanical work done on the farms in the locality, or that which should be done.

The third phase of high school vocational agriculture was the supervised farming programme, which was a compulsory feature of the whole scheme. This requirement was met in one of the following ways: a supervised farming programme conducted on the home farm; a supervised farming programme conducted on the school farm; group projects conducted on a school or other farm; supervised practice work done on an "approved" farm for which the student may or may not receive wages —sometimes called "farm placement"; actual management and supervision of a farm. As originally conceived, the supervised farming programme consisted of a number of "projects"—a project involving planning and doing all jobs connected with the cycle of producing and marketing any given farm crop, plant or animal. But at present, the conception of a completly developed farming programme went far beyond the idea of having the student carry as a requirement several different projects during the time he is in school, with perhaps little or no continuity existing between these projects. For each student concerned it had come to mean a steady building and growing into a farming business. The advantages of such a system of supervised farming were many: it provided exploratory experience in deciding what type of

farming to enter ; it developed abilities needed for proficiency in farming of the type in which the boy was likely to engage ; it showed how to earn, spend, save and invest money ; it developed judgment, abilities, skills, habits, attitudes and ideals concerning farming by providing real-life situations ; and it provided an opportunity for the boy to accumulate livestock, equipment and land, and so aided in establishing him in farming. Advantages to the teacher derived from making the supervised farming programme the logical core of the courses of study and by providing subject matter material for more practical instruction, while advantages to the community accrued from the contribution such programmes made to the efficiency of farms in the community by the introduction of standard and approved practices.

It was interesting to note that, where home farm facilities were available for these supervised farming programmes, there was no necessity for schools to operate school farms. But in areas where the population was tending to become urbanised, and where schools were experiencing the problem of having to train students in vocational agriculture who had no previous experience of farming and no facilities for supervised practice on home farms, there was a tendency for schools in such areas to operate school farms. In all cases, however, school farms were considered as merely extensions of laboratories, for purposes of teaching and demonstration.

Part-time Vocational Agricultural Education in High Schools

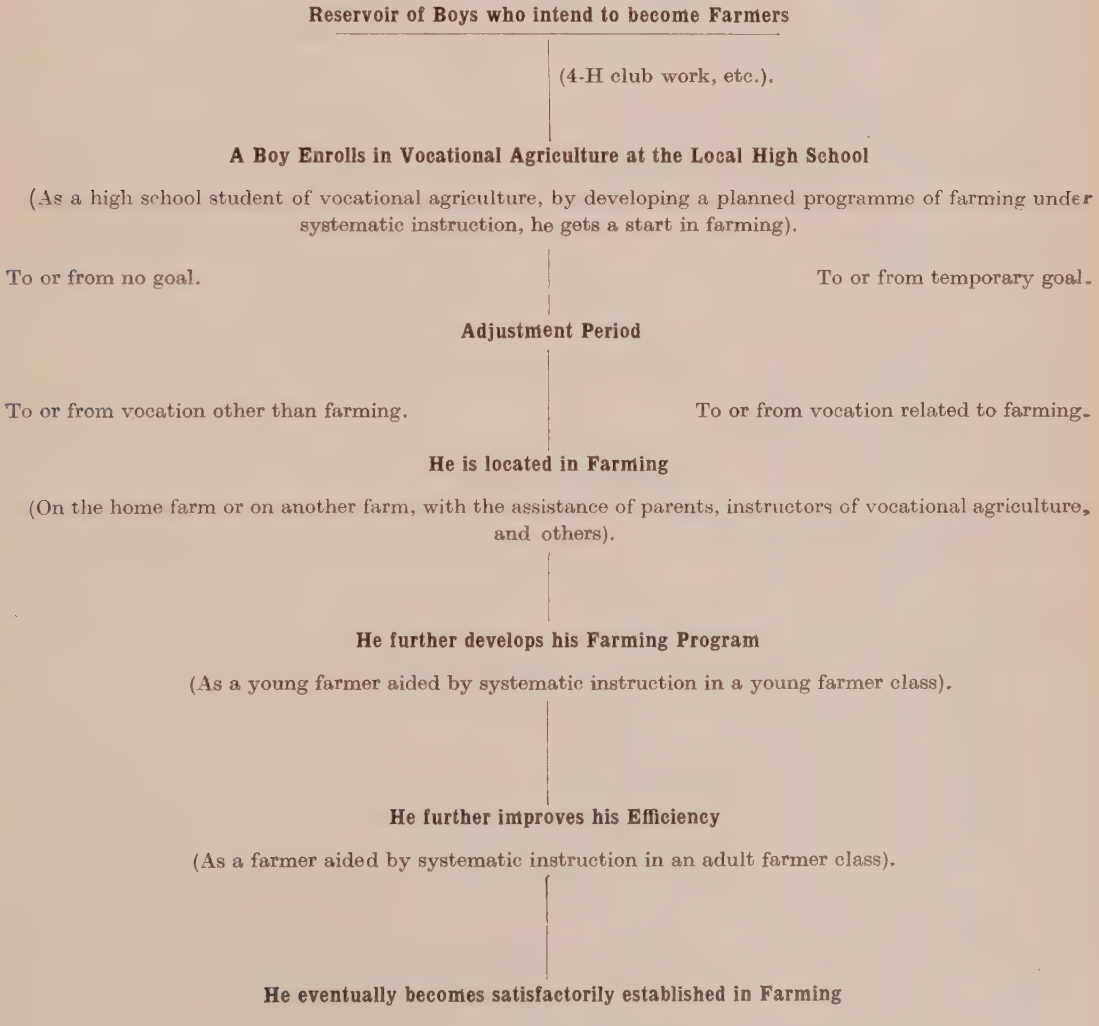
It will be remembered that the National Act governing vocational agricultural education provided for instruction in agriculture for young men not in school and for adult farmers, as well as for boys in school. This responsibility too usually passed to the high school department of vocational agriculture, and many young people, after they had left school and secured employment, arranged to attend some kind of part time school, which provided instruction in subjects meant to enlarge their vocational efficiency. Such classes were supplemental to daily employment and were usually held in the evenings in the high school department of agriculcure. All persons in the class had a common vocational objective and a common occupational background, farming, and here too the complete course consisted of class room instruction, farm shop work and supervised farming practice of a modified type.

Young-farmer teaching programmes provided instruction, also on a part time basis, for young men approximately 16 to 30 years of age, who were just establishing themselves in agricultural occupations. Because of the criticalness of this period in the establishment of young men in farming, when the temptation to leave the farm and migrate to the city was perhaps strongest, this young-farmer programme of instruction was considered a very important part of the total programme of vocational education in agriculture. Such classes were of many types : intensive classes which met daily for a specific period ; slack season classes held during the period when there was little work on the farm ; the long-intermittent type of class which met once or twice a month throughout the year ; and the classes which met 20 to 30 times about once a week during the slack season and held monthly meetings the rest of the year. These classes also made the high

school department of vocational agriculture their headquarters and instruction consisted once again of class room and farm shop work and supervised farming practice, modified and adjusted to suit individual cases. In deciding on the teaching materials for these classes, their characteristics as a group were considered and the managerial aspect was stressed.

Adult-farmer courses were for persons already established in farming, and consisted of discussions on subjects of general farming interest at which experts were sometimes present and the supervision on the farm of the practices and improvements discussed in the class. Usually ten or more meetings were held dealing with one or more specific subjects.

The diagram on this page illustrates the progressive developement through the total programme of vocational education in agriculture, which was meant to lead to successful establishment in farming.


Reservoir of Boys who intend to become Farmers
(4-H club work, etc.).
A Boy Enrolls in Vocational Agriculture at the Local High School
(As a high school student of vocational agriculture, by developing a planned programme of farming under systematic instruction, he gets a start in farming).
To or from no goal.
To or from temporary goal.
Adjustment Period
To or from vocation other than farming.
To or from vocation related to farming.
He is located in Farming
(On the home farm or on another farm, with the assistance of parents, instructors of vocational agriculture, and others).
He further develops his Farming Program
(As a young farmer aided by systematic instruction in a young farmer class).
He further improves his Efficiency
(As a farmer aided by systematic instruction in an adult farmer class).
He eventually becomes satisfactorily established in Farming

Almost all teachers and farmers were insistent that these young and adult farmer programmes conducted by the high school teacher of vocational agriculture did not in any way duplicate or interfere with the work of the Agricultural Extension Service, but that the two types of work being different, only supplemented and complemented each other.

Agricultural Education in Junior Colleges

The traditional system of grading adopted in the educational system of the United States was of the 8:4:4 pattern, with eight years of elementary or grade school, four years of secondary or high school, and four years of college or university. But within recent times, this pattern seemed to have undergone modification for a number of reasons, leading to the evolution of "junior colleges", "area vocational schools" or "technical institutes", where the first two years of university instruction were separated from the university proper. Among the reasons for the evolution of these junior colleges, including agricultural colleges and institutes, one appeared to be the increasing need that was apparent among high school students to continue their education in agriculture to a higher level, although not necessarily to a university level, due to an increasing demand for technically trained men at the semi-professional level, which exceeded the demand for technically trained personnel at the professional level. Accordingly, such junior colleges provided full time vocational courses in agriculture which led toward skilled occupation for which university graduation was not necessary, and in these cases, the term "vocational" tended to be replaced by such terms as "terminal", "semi-professional" and "occupational". Another reason seemed to be the need to relieve the burden of increasing enrolments in universities and the need to reduce the cost of university education, by providing the first two years of this education at a place close to the student's home. Thus, from the very nature of their origin, junior colleges served two functions: occupational or terminal and university preparatory.

Where such a course was terminal and occupational, it tended to follow the pattern of high school vocational agriculture, with class room instruction, farm shop work and supervised farming practice, while the course content was based on a careful survey of the agriculture of the region, the agricultural needs of the area, the experience of teachers of agriculture both at the college itself and at the high schools served by the college, and on continuous checking with practicing agriculturists in the area. The consensus of opinion among educators seemed to be that much further development could be expected in such post-high school terminal education in agriculture. Where, however, emphasis was on the

university preparatory nature of the course, the entrance requirements of agricultural faculties of universities were kept in mind, the course content being arranged rather with these prerequisites in view, and arrangements being invariably made with universities for students to transfer there after two years.

Short Courses in Agriculture at State Colleges and Universities

In addition to their regular four year courses in agriculture leading to the Bachelor's degree, most universities had a two year programme for students to obtain an Associateship, Certificate or Diploma in agriculture. These courses were designed for persons, often already engaged in farming, who wished to train in agriculture without undertaking a four year training leading to an academic degree, or for high school students preparing for an agricultural or related occupation not requiring an academic degree, or for those high school students who could not qualify for entrance to a university. Such programmes stressed technical and practical training appropriate to the particular area, but were tending to be replaced by the occupational and terminal training provided at junior colleges. At some universities it was possible for students to transfer from this two year programme to the regular four year course, whenever they desired to do so, if their work in the former had been satisfactory.

Finally, almost all universities offered short courses in agriculture which varied in duration from a few days to as much as six months. These short courses were more in the nature of agricultural extension, and were offered primarily for those who desired a training in a particular field of agriculture but could not avail themselves of a longer course, and for those desiring to keep abreast of the rapid developments in special fields of agriculture and rural sociology.

Training of Teachers of Agriculture

Any programme of agricultural education is likely to be no better than the teachers employed, and it was interesting to note that the training of teachers of vocational agriculture was invariably conducted in the agricultural faculties of universities and not at teacher training institutions. The courses in agricultural education offered at universities were so constructed that the teacher was not only competent in the field of education, but also in the field of agriculture. Competency in the field of agriculture was considered absolutely essential, as a teacher's normal work was not confined to high school students alone but also to young and adult farmers as described earlier, and embraced not only his particular department in the school but the whole rural community. It was generally felt that an individual desiring to become a teacher of vocational agriculture should have actual farm experience, since it was difficult for him to appreciate properly the problems facing farm people if he had not experienced them himself, and since the actual experiences and skills learnt on a farm were invaluable to him in many of his teaching problems and in understanding the thinking and reactions of rural people. Thus, undergraduate preparation for the credential to teach agriculture included, in addition to technical subjects and participation experience, three years of

farm experience or its equivalent, and students who were not so qualified usually had to arrange for summer work through the university.

Extra-curricular Activities related to Vocational Agricultural Education

Parallel to this continuous programme of formal agricultural education, and in fact complementary to it, was a programme of extra-curricular activities organised and designed to cater to the different age groups of rural people. Such activities not only provided the desired out-of-school atmosphere which made the formal education more effective, but also catered to the emotional needs of the age groups concerned, and by providing some of the amenities that rural youth lack, tended to create in them a love for the land and the implied way of life.

Catering to the needs of the youngest age group were the network of 4-H clubs, similar to the Young Farmers Clubs of Ceylon, which were fostered by County Extension Agents and were under the guidance and leadership of adult voluntary workers.

Serving a somewhat different age group and class were the Associations of Future Farmers of America (and New Farmers of America for negro boys), organisations restricted to boys studying vocational agriculture in high school, and having aims fairly similar to those of 4-H clubs : to foster a love of farm life ; to encourage participation in social, agricultural and community activities ; to teach leadership ; and to serve as an indirect means of spreading agricultural knowledge. But there was a close tie-up between the activities of these organisations and the supervised farm practice inherent in vocational agricultural education, because, although the boys initiated and directed their own activities, each school "chapter" was under the guidance of the vocational agriculture teacher, who served as advisor and worked with the boys every day at school and supervised their farming operations at home. In addition, there was a definite and conscious attempt made through these organisations to establish these students in farming. Thus, each member kept a record of his farming operations and, on the basis of achievements in this field, competed to rise through the four grades of active membership in the association—Greenhand, Chapter Farmer, State Farmer and American Farmer. At the annual National Convention, the national office chose a boy from each of the four different regions of the country as a Star Farmer, also under the basis of his achievements in farming under the supervised farming programme, and from these four was chosen the Star Farmer of America.

Young Farmers Associations in the different states were organisations of young men between high school age and the age when men normally become active members of a farm organisation for adults, such as the National Grange, the Farm Bureau Federation or the Farmers Union.

Basic Farm Training

In certain parts of the United States teachers of agriculture were beginning to face a problem which is of fairly common occurrence in Ceylon today : namely, the problem of the city boy or young man with no previous agricultural experience or background who desired to study vocational agriculture.

It was obvious that a basic knowledge of farm skills and operations was essential for almost any job in agriculture, and it was equally apparent that a city boy who intended to study agriculture could usefully acquire the skills that could normally be expected of a boy that had grown up on a farm. Thus, it was felt that practically all students who studied agriculture could profit by spending some time on work in a farm.

In some states this requirement was met by insisting that all boys who intended to study agriculture should, as a prerequisite, have sufficient farm experience. Where this was not possible, however, some agricultural institutions encouraged students to work on a farm during their vacations and took steps to place them on farms if they were unable to find suitable places for themselves. On the other hand, some institutions preferred to give students the necessary experience and skills on their school farms themselves, these farms being mainly designed for this purpose, while still other institutions had elaborate arrangements for providing students with this basic farm training through a very complete placement service, operated in co-operation with selected farmers in the district.

Guidance, Counselling and Placement

Vocational guidance could be defined as the process of acquainting the individual with various ways in which he could discover and use his natural endowments so that he could live and make a living to the best advantages of himself and society. Guidance and counselling seek to conserve, develop and use for the best interests of society the greatest resource of a country—the potentialities of its men and women. In view of the great number of vocations and the limited opportunities most youth have of getting work experiences and opportunities to study occupations before they have to make up their minds what vocation to enter, the need for guidance and counselling is evident.

Agriculture has too often become the "dumping ground" for boys who are unable to succeed in their other studies. Management of a modern farm or agricultural business calls for a high level of ability and it is unfair to a student to lead him to believe that he could succeed in an agricultural profession when far better outlets for his limited abilities are available in other occupations. As detailed earlier, vocational agricultural education can be successful only on the assumption that the students have made a choice of an agricultural vocation on the basis of an intelligent decision. Thus, once again, the need for vocational guidance and counselling becomes evident.

Most educational institutions realised the importance or guidance and counselling in vocational education, and through a bureau of student personnel, carried out a programme of guidance which varied in effectiveness, published regular information on agricultural opportunities and the requisites for entering different fields of agriculture, and as a natural corollary to a programme of guidance, endeavoured to place the students in suitable jobs after they had completed their course.

Conclusion

Agriculture is not only an art and a science, but also a vocation and a mode of life, and as such, if a scheme of agricultural education is to be at all

successful and serve the purpose for which it is intended, it must be closely attuned to the way of life and mode of thinking—the culture—of the people of a country. It is very unlikely that the organisation of agricultural education in a country like the United States, which has been designed to suit that country, could fit a country like Ceylon, or that the methods and techniques of teaching agriculture adopted there could be taken over wholesale into this country. But in spite of all differences, certain basic principles underlying a scheme of agricultural education as well as certain fundamental concepts concerning the teaching-learning process, which depend on essential similarities among people working on the land and with the soil, always remain the same. It is hoped that this paper will enable the reader to recognise some of these basic principles and concepts, and by seeing how they are tackled in other countries, stimulate his thinking to arrive at solutions to local problems.

Publicity: Key to Increased Production

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The Contribution of science to agriculture in the past was not great—varieties were discovered rather than bred, the virtues of lime, linseed cake and organic manures were discovered by farmers and not by scientists, hence it was only natural that practical men scorned theory. But since then the impact of science has become progressively more important. In fact, the increasing complexity of agriculture brings problems that are beyond the resources of the individual farmer.

Recognising that these difficulties can be met through the application of scientific investigation, Government has established a number of experimental stations and research laboratories ; provided assistance programmes and protective services to serve the needs of a wide variety of farming enterprises, involving soil management, the development of improved cultural practices and superior types of plants and animals, pest and disease control, the introduction of farm machinery and other aids which make for greater yield and more efficient use of labour.

THE NEED FOR PUBLICITY

Indeed, today the world farms by science rather than by tradition. The modern farmer is a businessman. He invests on chemical, feed, fertiliser, seed and the like and expects a good return. Unless he is told about new ideas and helped to use them to increase his yields, to lessen his labour and to rid him of a series of hazards that he has come to recognise through the centuries as inevitable, his enthusiasm wanes and production stagnates.

Progress does not provide an unmixed blessing. For instance, tremendous harm can result from the toxic effects of insecticides used negligently or in ignorance of some of their subtle effects ; unforeseen conjuctions of heat and rainfall on an applied weedicide or its improper application can turn an intended precaution into any unpremeditated disaster. Mistakes of this nature can wreck agricultural progress hence the need for extensive publicity before the introduction of such measures.

Publicity is a necessary adjunct to salesmanship. To translate the statistical semantics of agricultural research and to put over a new scheme to the tradition-bound peasant is, indeed, salesmanship of the highest order. For even when the advantages of a new discovery are abundantly clear, the peasent tends to hug the things he is accustomed to. It takes a great effort to win him over to a new idea—much informatory spade work is necessary.

The latest authoritative estimate of the total expenditure on advertising

in the U. K. is £170,000,000—£185,000,000 for 1950 (*Advertising Expenditure*—Rodney Silverman). In the U. S. A. the comparable figure for 1950 according to *Printer's Ink* was 5,691,000,000 dollars. Expenditure of this magnitude is surely an answer to the critics who consider advertising improvident.

Government advertising seeks to educate the public in the use of a product or practice without any direct attempt to create sales, in contrast to commercial advertising, where the emphasis is on boosting sales. But the fundamental principle is the same, whether it be to sell an idea or a product. Advertising, it is said, lubricates the wheels of commerce ; planned publicity may well be used to boost agricultural progress and stem the migration from peasant plot to city slum.

PLANNED PUBLICITY

The most effective media for disseminating information to the farmer and those directly concerned with his welfare are viz :—Press, Posters, Bulletins and Direct mail, Films, Exhibitions and Demonstrations, Radio and the Spoken Word.

Press

Newspapers. The newspaper is a powerful organ reaching out even into the backwoods. It is a great pity that it has not been sufficiently exploited to serve the needs of the farmer. Ever so seldom the leading dailies carry an agricultural supplement ; perhaps once a year meagre publicity is given to inaugurate an Island-wide agricultural drive, which peters out within the week, or sporadic news is published that is often unauthenticated, incorrect and misleading. What is needed is a spirited new approach whereby editorial publicity as opposed to advertising publicity may be accomplished through news columns, feature columns, photographic pages and special columns. The correspondence columns too should not be neglected ; even a few published letters will set the ball rolling as readers write in and say what they think.

With growing experience has come the realisation that it is important to coordinate publicity with the actual operation of agricultural practices. For instance, it is necessary to advise farmers to manure their paddy or spray their crops against pests and diseases. This is most effectively accomplished by urging them what to do just before the main cultivation seasons or with the actual outbreak of a major pest or disease. When one visualises the countless hazards that have to be dealt with or the numerous improved practices that need publicity throughout the year it is not difficult to realize that there will be a wealth of sustained material with which to feed the press. An arresting headline, a quarter column or a telling picture will often suffice, and as the daily papers are the quickest way of reaching the farmer in an emergency, such publicity will eventually break down the barriers of tradition and reap rich dividends.

Advertising publicity too should be considered in relation to effectiveness and cost. Illustrative advertising is generally more understandable. The popularity of narrative advertising, relying on an illustrated story, is steadily increasing and may be used to

advantage. If more than one medium of press advertising is employed, a "keying" system may be adopted to determine which medium is best patronised. For example, a coupon entitling readers to free information will indicate the response of interested readers ; a desk number for each medium will tell which medium is best patronised.

Magazines and Periodicals. In a country like Ceylon the newspaper is possibly the chief reading matter of the people and therefore a most potent publicity weapon, but one must not lose sight of the value of popular magazines and periodicals that are usually aimed at a smaller technical or class public. Although both periodicals and newspapers are of ephemeral value, the life of the former is longer than that of the newspaper which is usually discarded the moment it is read.

The disadvantage of the agricultural magazine is its difficulty to survive in an age that is flooded with a diversity of good and spurious literature. To compete with such odds the agricultural magazine has to be an ambitious pubcation, but yet within the competitive price range of other magazines. Whether the publication of such magazines is a worthwhile venture is a moot point, for there is that pertinent school of thought which maintains that the very small public that demands such a magazine will look out for it and purchase it irrespective of a fancy get-up or not. But there is no gainsaying the fact that the agricultural magazine, with or without trimmings, is the way to cater more succintly to the literate and discerning farming community. As such it should find a place in any publicity campaign.

Posters

Posters are broadly classified into two kinds—the pictorial and the letter press or all type variety. Where the majority of the farming community is poorly literate or illiterate, the pictorial poster is the most effective ; it also stands competition with the ubiquitous galaxy of commercial advertising.

It is no longer sufficient to fill a given space with a drawing ; today the drawing must attract and easily convey its message to the reader. In the first place we must appreciate that the poster, in most cases, is to be read by a mobile public ; it cannot be carried into the home like the paper and read at leisure. The poster, therefore, must not only be attractive enough to compel attention against a distracting background of scenery and movement, but its message should also be concise and pertinent to catch the readers' eye. In brief, the poster must conform with the accepted principles of sound poster advertising—its design should be clear, cheerful and arresting, its message brief and to the point and it should also indicate to the hurried and casual observer where he may get further information. Humour is universally employed in the poster technique, but humour is two edged and should not be used except by the keen of wit. The sparkle of vivid spontaneity is essential, for nothing is more destructive than heavy handed attempts at humour.

Agricultural posters, which are chiefly directed at the rural populations have a distinct advantage over their commercial counterparts which predominate the towns and urban

districts, in that in the country there are less distractions and people have time to stand and stare. The poster is, therefore, one of the most valuable media of agricultural publicity. But, of course, one must realise that a poster cannot stand on its own ; it is really a first line of attack meant to arouse interest and create a desire for more information ; which should be supplied in the form of bulletins, films, demonstrations, lectures and other media.

No matter how beautiful the poster may be or how effective its slogan, it serves no useful purpose unless well displayed. This brings us on to the problem of sites, and in this instance it is well to remember the accepted axiom of sound poster campaigning, namely, that the site is more important than the poster. The haphazard method of bill posting on the hit-or-miss principle is wasted effort and shows a poor sense of administration to say the least. A poster may be made to work for its living for a longer period if proper sites are chosen for its display. In this context, it cannot be too strongly urged that Government erect permanent hoardings in every rural village to contain these posters. The problem of maintaining these hoardings should offer no obstacle whatsoever, beyond regular inspection by the Extension Service, who are responsible for the direction of agricultural propaganda in the field.

In addition to hoardings, posters should be displayed in as many public places that are frequented by the people you are trying to interest—bus-stands, railway stations, village fairs, markets, post offices, schools, village halls, co-operative societies, young farmers' clubs, agricultural offices, etc.

The size of the poster will be determined by the nature of the campaign and the cost of printing. The double crown serves most purposes, but in national Island-wide campaigns of a permanent nature (Tree Planting Campaign, Soil Conservation Campaign, etc.) it is well worth printing large posters in addition to the smaller ones, which may be used for field circulation. The larger posters may vary from the two-sheet to the thirty-two sheet in size.

Willi Günhart designed the perfect poster for Gesarol. Even after ten years it is still to be seen on hoardings and shop windows in Switzerland. The Hastings Holiday Resort poster is well known in Great Britain and has enjoyed several years without loss of prestige. There is tremendous scope and need for similar posters in the agricultural field in Ceylon.

In the initial conception of a poster, especially the large sheets, it is essential to plan for "slipping". By this process posters may be brought up to date in topical detail without incurring the cost of colour-printing an entirely new poster.

Bulletins and Direct Mail

The bulletin is perhaps the most important medium of instruction if imaginatively conceived. Our farmer is not a natural reader and any reading matter that is directed at him must, therefore, be entirely popularised, profusely illustrated, simply but

stimulatingly written to appeal to his slow and rather conservative way of thinking and shorn of all confusing verbosity.

Experience has shown that the folder is the most popular form of bulletin. Photo-folders with a bare minimum of letter press are more expensive to produce but are most effective.

The abundance of commercial "give-away" literature is of little consequence to the Ceylonese farmer, because he is too poor or socially insecure to afford most of the products peddled by commercial establishments. Moreover, he is still chary of advertising, which he considers a stratagem used by sharks to line their pockets at his expense. But this suspicion is being gradually dissipated by honest merchandising specialists, primarily concerned with the marketing of fertilisers, pesticides, fungicides and like, who have vast canvassing organisations that are bringing these products slowly but convincingly home to the farmer.

Here then is a glorious opportunity to use the bulletin as an advisory medium to instruct the farmer in the use of new and improved products. Teaching him to use them serves both agriculture and industry. Bulletins should also tell of the many protective and assistance services that Government offers. The guaranteed price scheme, subsidized fertilisers, the bull-calf exchange scheme, artificial insemination and stud centres, veterinary dispensaries, the formation of live-stock breeders' societies, free poultry vaccination are a few of the many services that are starving for want of organised publicity.

The problem of ensuring that these bulletins reach the farmer is a serious but not insoluble one. Obviously it would be impossible for a direct mail campaign to be launched at every potential farmer in the Island. It could be tackled, however, on the same principle as a manufacturer propagates his message through the retailers who handle his products. The Department of Agriculture can confine its efforts in the medium of direct mail to the Agricultural Extension Staff individually, who will act as distributors to the farmers in their respective districts. This scheme may even be enlarged to include other Government organisations that have direct contact with farmers viz., District Revenue Officers, Rural Development Officers, Village Cultivation Officers, Colonisation Officers, etc., depending on how well equipped and staffed the central distributing office may be.

In addition to bulletins, the distribution of saleable publications like magazines to the Extension Staff will help further the projection of the message. If these are displayed in clubs, schools, agricultural offices and similar places where the literate public may be expected to congregate, sales will be possible. In the villages, the life of a periodical is considerably longer than in towns where other literature tends to detract from its interest in the general rush for topicality.

As an adaptation of the poster, it is also desirable to distribute to the Extension Officer picture and feature sets. These are a series of mounted glossy photographs with descriptive captions depicting various improved practices. These may be displayed in his office or in some public place where they can be verbally interpreted. By this means the farmers are kept aware of Government activity in the field of agriculture and the extension worker is provided with a valuable aid to instruction.

The Extension Officer is directly concerned with the execution of the agricultural message and as such it is imperative that he be kept abreast of current research, and publicity campaign policy. A monthly news letter embodying these items with suggestions as how to best employ them in the furtherance of Government objectives should be sent to him regularly. Sometimes it may be even necessary to issue him with emergency directives on changes of policy etc.

The system of direct mail is the most satisfactory means of reaching the farmer on his own ground. It gives him the incentive to further production and effort in the realisation that he is backed by an enterprising and helpful Government. Moreover, it supplies the Extension Service with the necessary ammunition to wage a successful battle against the weighted tradition of the peasant that keeps him from being progressive minded. It also serves to inspire confidence in the mind of the Field Officer to know that he is an important unit in a friendly and efficient organisation, rather than a lone and often forgotten individual operating on his own.

Films

The "silver screen" is probably the chief form of entertainment in this country today; therefore its value as a medium for propaganda should not be underestimated. So highly is this medium rated by the Ceylon Government that it is the only one for which a special unit exists—the Government Film unit, whose chief function is to produce films about Government activities. The trade has already invaded the field of film publicity. One is quite accustomed to seeing their products advertised by slides or the more recent "two-minuter", which as its name implies is a sponsored film carrying an advertising message that runs for a maximum of two minutes. How best can we use the film to serve our needs? Which type of film is the most advantageous in the cause of agricultural publicity? These are the questions that have to be first answered before the publicist can plan his campaign. Films are broadly categorised, in the phraseology of the film industry, into those produced for theatrical and non-theatrical distribution.

The 35 mm Film. Theatrical films are 35 mm in size. They are usually shown in cinemas to which audiences pay an admission charge. In the first instance, therefore, it is apparent that this type of film has got to be of a quality *par excellence* if it is to impress at all. The production of such a film is a costly affair and can only be attempted by a

fully staffed and equipped organisation. The magnitude of the task can only be appreciated if one examines the progress of the production of such a film from the point of scripting through the various stages of shooting, dubbing and copying for distribution. The theatrical film is definitely not for the amateur impresario.

It is here that the services of the Government Film Unit can be profitably harnessed to bring before the people the benefits of scientific farming, and to show some of the achievements that has been made and are being attempted towards a more prosperous agriculture. The function of this Unit can greatly enhance the projection of the message through the showing of documentaries and feature films that will familiarize people with Government development schemes, aid and facilities to the farmer. Features like "Farming's Chemical Age," "More Food for the People," "The Department of Agriculture at Your Service" and "Milk Builds an A I Nation" are a few ideas that immediately spring to mind.

16 mm Film. The non-theatrical film is for the most part produced in the 16 mm size. Although it has certain limitations as regards size of audience there are many advantages in its favour that warrant its serious consideration as a valuable visual aid.

Its production is comparatively simple and well within the compass of a departmental audio-visual unit. 16 mm film is non inflammable and no licence is required for screening it—this aspect opens up a larger field of possible audiences than the theatrical film. The 16 mm film should be therefore ideal for screening at Field Days, Exhibitions and such agricultural gatherings in support of other more informative and educative publicity media.

Films may be distributed to Extension Staff that are supplied with projection machines or it will be possible to arrange for travelling units to tour the agricultural districts. A fair amount of prior publicity and the arrangement of a programme judiciously spiced with films of entertainment value will assure success. It must be realised that rural populations are starved of entertainment, a tactful publicist or campaign manager will not, therefore, limit the performance to a showing of agricultural films only, he will include one or two feature films loaned from the departmental film library or from outside.

Film Strips. As an effective medium of instruction, however, the film strip is more important than the 16 mm film. Essentially it is a more effective and portable form of the magic lantern. The apparatus consists of a projector through which a series of "stills" are shown, an explanatory commentary being delivered at the sametime. In constrast to the 16 mm film where only an overall idea can be obtained by the audience, the film strip permits of detailed explanation and allows time for discussion. As such it serves as an ideal aid to the Agricultural Instructor propagating a new practice. The wise propagandist will use a judicious mixture of 16 mm film and film strip to put across his message. The 16 mm film will provide a

brief respite from the concentration necessary for following attentively the various frames of a film strip.

Film Library. If it is to be assumed that the Field Staff will be supplied with projection apparatus, the need to feed these units will arise. To fill this need a substantial library service should be established not only to cater to the Extension Staff but to meet the constant demands of schools and other institutions.

The life of a film is by no means over when it has completed its road-circuit, provided, of course, it is not so topical that it dates early. Once a film has served its immediate purpose it is wise to file it in a library, so that it may yet continue to work for its living.

Exhibitions and Demonstrations

Although exhibitions are embryonic in this country, their popularity and effectiveness as publicity and propaganda media are well recognised in other countries. Take, for instance, the many exhibitions that cater to a variety of needs in Great Britain alone—The Ideal Home Exhibition, The Royal Agricultural Show, The British Industries Fair, Britain-Can-Make-It Exhibition, The Festival of Britain, to mention some of the biggest, besides local and celebratory exhibitions like the Dairy Show, Motor Show, Bicycle and Motor Cycle Exhibition, Radiolympia, the Building Trades Exhibition and many more. In overall size the agricultural shows are the largest regularly held in Britain. The Royal Show alone covers an area of 100 acres and moves annually from county to county. 110 smaller agricultural shows were also held in Britain during 1948. Before considering the types of agricultural exhibitions that could be best employed to satisfy the needs of this country it is necessary to briefly review the general principles of exhibition technique.

Exhibitions constitute the most satisfactory medium for education and propaganda when they are concerned with actual physical exhibits or demonstrations; they operate on the principle of "to see is to believe." Seeing objects in the round is more impressive than any two dimensional representation, however tastefully displayed. Typography, photographs, paintings, diagrams and illustrations play an essential part in conveying technical or original information, especially to the faming public who are more respective to visual images than to the spoken or written word, but the interest of the visitor should be preferably captured by three dimensional objects and then directed to the supporting two dimensional material. The exhibition should be so laid out as to provide sufficient excitement at the entrance to carry the spectator through a constant change of visual interest on a sustained wave of attention. The message should be simply and forcibly conveyed, but with sufficient subsidiary information to satisfy the more enquiring, yet without vitiating from the power and simplicity of the main message. Showmanship is an essential quality of successful exhibition technique, for the show must interest and if possible entertain. The practitioner of this medium of display and

A part of the Department of Agriculture Pavilion at the Royal Agricultural and Food Exhibition held in Colombo (January-February, 1956)

The Shell Stand by night at the Royal Agricultural and Food Exhibition, Colombo

promotion has to be constantly seeking new methods to lighten the dough of "routine exhibition" with the leaven of "attractions" which have to be provided as a relief and bait for publicity.

Agricultural Exhibitions. Agricultural shows may be envisaged as provincial exhibitions or more local affairs. The *Provincial Show* should be organised in conjunction with the agricultural trade and must necessarily be the star attraction, so to speak. It should move from province to province annually and have a duration of not less than a week. Besides elucidating the latest trends in agriculture it should serve as a judging ring for livestock, a demonstration ground for manufacturers of agricultural products, machinery and supplies, a rallying ground for the rural community to meet informally, exchange opinions and discuss their problems with technicians and experts of the Department of Agriculture and the manufacturing firms represented at the exhibition, and finally as a fair ground that provides harmless entertainment.

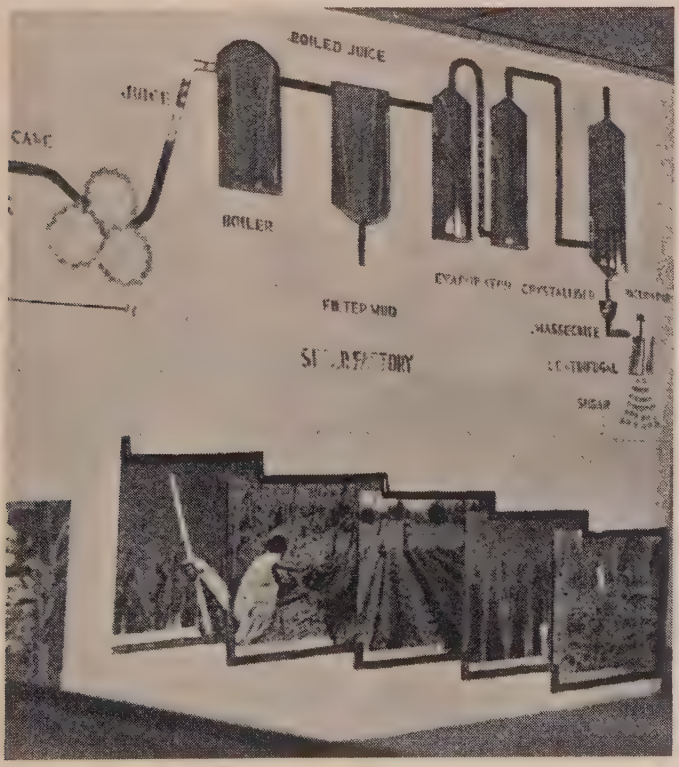
The *Local Show* is much less ambitiously conceived—in fact it should be planned to cover a one or two day duration at the longest and to meet the particular requirements of any one area. As such it cannot be used as a sole medium of propaganda, the most it should aspire to is that of supporting role to other media brought to a foucs at an agricultural rally, field day or some such function.

Unlike its bigger brother, the provincial show, the local exhibition must needs make do with whatever accommodation is available on the spot —the *gansabawa* hall or school room in all probability or it will have to be housed in a tent or marquee. In either case, the exhibits must necessarily be self supporting display units that are easily transportable. This will entail much expenditure in the preparation of a sufficiency of exhibits readily available to the Field Service. But the comparatively high cost of exhibitions will, I am sure, be commensurate with the response.

Other Exhibitions. One must also consider the justification for participating in exhibitions other than those primarily concernd with agriculture and which are not sponsored by the Department of Agriculture. Although such exhibitions are not a common feature in Ceylon, there is growing trend towards their popularity as witnessed by the Colombo Plan Exhibition, Royal Agricultural and Food Exhibition and the Sambuddha Jayanthi Mandalaya Festival held in recent years. One cannot hope to bring everyone to the major agricultural shows, but by participation in other shows it is possible to bring agriculture in a limited way to a larger number of people.

In this case the agricultural display, which should be restricted to a small stand, must be keyed to the particular theme of the host exhibition. It should only attempt to create a general impression in the mind rather than provide visitors with detailed information. The mass of facts, the reasoned argument are out place when addressed to very general audiences. What is important is that the visitor may carry in his mind an idea that might later affect his actions. To capture the attention of the hurrying, crowd jostled visitor, it is

A portion of the Veterinary Section in the Department of Agriculture Pavilion, showing the use of humorous cut-outs to draw the attention of the public to the more technical exhibits displayed below (Royal Agriculture & Food Exhibition 1956)



Moving exhibits attract the most attention. The picture shows an electrically operated flow-chart of a Sugar Factory. This exhibit was very popular both at the Colombo-Plan Exhibition, held in 1953 and The Royal Agriculture and Food Exhibition, 1956

necessary to resort to special mechanical display devices and a multitude of ingenious tricks solely designed to catch the eye.

Field Demonstrations. Demonstrations of this nature, though shorn of the glamour of the exhibition constitute the most vital method of convincing the farmer of the message. It is unfortunate that demonstrations today are often conducted in a dull and dispirited fashion. A successful demonstration, in every possible instance, should be concluded with a publicity "tamasha" to drive home in no uncertain manner the value of the new practice or product demonstrated. Demonstrations are the responsibility of the Extension Service and therefore not within the purview of this article, but they are mentioned here merely to illustrate how much more can be accomplished by close collaboration between the Publicity and Extension Services.

Radio and the Spoken Word

The radio, as a medium for advertising, has been thoroughly exploited by the Trade; in fact the Commercial Radio owes its existence to commercial advertising. In the U. S. A. the majority of radio programmes is sponsored by advertisers.

The basic premise of radio advertising is its function to entertain. It must be realised, therefore, that however brilliantly the message may be conceived, if the entertainment is inadequate, the listener, with a flick of his finger, can consign the most expensive programme to oblivion. Commercial radio advertising is therefore a task outside the scope of a departmental publicity organisation.

Radio publicity at present is necessarily limited to those people who own radios. The message should be adapted to meet their requirements. A weekly or fornightly feature by an expert on a particular subject, ably supported by successful practical men in that line will be useful publicity that packs a punch. Special broadcasts by distinguished personalities to inaugurate a new drive are also successful if properly produced.

The radio, in conjunction with editorial publicity, can play an important role in alerting people, for instance, to the incidence of pests and diseases in epidemic proportions and advising them how to combat such vicissitudes. This is a facet of radio publicity that has not been explored yet, probably due to a limited radio circuit, but if a special appeal is made along with the emergency broadcast to listeners to pass on the information to those who haven't the advantage of a radio, I am sure, the response will be encouraging and the results heartening.

It is to be hoped that with the advent of re-diffusion farming families will soon possess receiving sets. Under these conditions the power of the radio as a publicity medium will be enormous; till then its coverage is restricted.

Referring to spoken-word-publicity in general, it may be briefly stated that straight lectures or addresses are of little value to the farmer unless used in conjunction with other media. A poster, bulletin, or advertisement may indicate clearly and trenchantly the advantages of following a certain course, but it is the spoken word that has the authoritative ring of personal experience.

ORGANISATION

The Ceylonese farmer for all his love of tradition is not too hard to convince once he sees a definite result. Organised publicity is the only way to achieve this end. The aim of the publicist should be to keep the message fresh in the minds of the people. To do this successfully he has to use all the media already discussed in close collaboration with the field extension service, who are directly concerned in implementing the message and with the co-operation of Press, Radio, State Information Office and Government Film Unit. This automatically creates problems of supervision and continuity that are beyond the reaches of our ghost organisation at present. It calls for co-ordination in all those branches concerned with painting, writing, typography and photography ; it demands a fluent knowledge of oratory, folklore, mythology, psychology and the showman's art, all of which to a greater or lesser extent play their part in the execution of a planned campaign. However brilliantly conceived or splendidly produced the various media of publicity may be, unless co-ordinated into a concerted campaign they are only fit for salvage.

Both the copy and printing departments should carry a full complement of qualified staff. It is these two departments in close co-operation with the photographic section that will be responsible for a continual flow of posters, advertisements, bulletins, booklets, broadsides, etc. which form the bulk of the publicity material.

An important section connected with them will be the distribution agency, whose purpose it is to see that the attractive material produced by the creative departments do not accumulate in the store, but find their way immediately to those for whom it is intended.

A Publicity Organisation will find it necessary not only to maintain liaison with Press, Radio and Film executives but will need to specialise in preparing scripts for broadcasting and filming in much the same way as the poster section prepares roughs and finished drawings for the colour printer.

The display and promotion section will comprise a large staff consisting of executives concerned with organisation and liaison with the Field Service in addition to carpenters, electricians and other technicians responsible for the manufacture and installation of the many exhibits that are designed by the visual aids section for exhibitions and demonstrations.

And last but not least, the Organisation must maintain an Information Bureau, staffed by charming and capable ladies, whose duty it will be to deal with all inquiries courteously and efficiently. They should be supplied with all types of extension literature for distribution to the interested visitor. A brochure entitled " At Your Service ", preferably published as a photo-journal, telling of the many services offered to the public by the Department of Agriculture should be made available free to the public.

Success starts a long way ahead of the point where artist or copy writer sets pencil to paper. It starts with the campaign policy. The importance of deciding on a satisfactory copy theme that forms the basis of a campaign

cannot be too strongly stressed. The repetition of this theme throughout the different media cannot fail to penetrate.

To be outstandingly successful publicity must be unfettered, alive, fascinating and timely. Planning must be highly flexible to meet each new challenge from whichever direction it appears. In this respect it is regrettable that Government departments are handicapped to a certain extent by their dependence on the Government Printing Press. This is in no sense a derogatory implication of that excellent institution, but it must be appreciated as a factor that affects the timeliness of campaigns.

A Publicity Organisation must confine its activities entirely to ways and means of propagating the message, it should not burden itself with the preparation and distribution of departmental publications and other material that are alien to publicity. These publications rightly fall within the function of the Government Press.

It is evident that to achieve the results, which it is believed our present efforts in agriculture will bring about demands adequate publicity. The most cursory scrutiny will show that much has to be done in the way of formulating an efficient policy and in the acquisition of skilled personnel and specialised equipment to make the present organisation grow to the point where it can be called a material manifestation of the present shadow box structure.

In conclusion it may be well to reiterate that successful publicity hinges chiefly on the harmonious relations of research workers, publicity men and that band of extension workers whose fingers are on the pulse of the farming community. The research worker discovers something of promise ; it is tested, proved and transmitted through the copy writer and visual publicist to the farmer, wherever he may be. From there on it is the responsibility of the Field Extension Service to consolidate the initial success with a bold and untiring spirit of enterprise that will ensure the fruition of these activities.

Feeding of Cattle in Ceylon

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Animal Nutrition though a comparatively new science, has made such rapid progress within the last decade that it has profoundly affected the practice of the feeding of animals and has resulted in greatly increasing the efficiency of production of livestock. Animal nutrition deals with the scientific principles governing the requirements of animals for their maintenance and production. Under the term production is included growth, work, fattening, reproduction and the production of meat, milk, eggs, wool, etc. The study of the factors affecting production and the application of this information to feeding practice is of paramount importance to the development of a country's livestock industry.

Two interacting factors determine growth, production and reproduction in living organisms, viz., heredity and environment. The conditions under which an animal lives and nutrition make up the environment. Thus for example a pedigreed cow of a high milk yielding breed, will not be able to maintain her production without proper nutrition and her progeny will not be able to express fully the inherited milk yield quality under adverse environmental conditions. Therefore in endeavouring to improve the cattle in any particular area by the introduction of better breeds the food available to them in that area must receive prior consideration. A cow in its wild state, in its natural habitat, is normally able to procure its food requirements within a limited range. In these circumstances the cow is only required to provide sufficient milk to rear its calf. But in the case of the domestic animal it is required to be a milk producing machine, giving 10,000 to 20,000 lbs. of milk per year. The nutritional requirements of such a cow will necessarily be very much larger.

It has been said of the cattle in India that with better feeding and management the milk yield can be increased 100 per cent. This applies to cattle in Ceylon to as great an extent. It is no exaggeration to say that proper feeding and management will double the yield of milk almost overnight, whereas 25 years of breeding will only increase the yield 15 to 20 per cent.

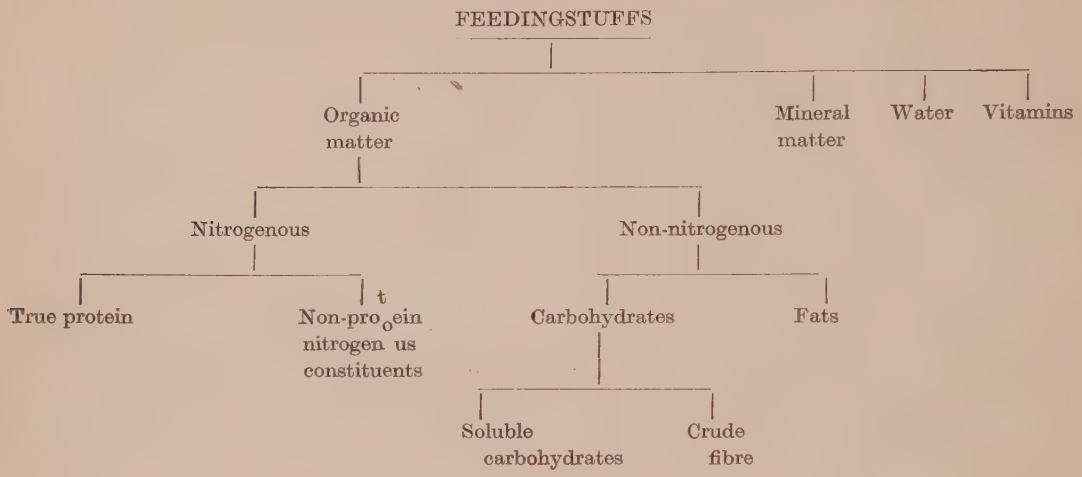
Feedingstuffs

Feedingstuffs may be grouped into three classes as shown below :—

FEEDINGSTUFFS

Concentrates	Green roughages	Dry roughages
1. Seeds of cereals, pulses and oil-seeds	1. Green fodders, grasses, legumes, &c.	1. Cereal and legume hays
2. Oil cakes	2. Roots and tubers	2. Cereal and legume straws
3. By-products of food grains	3. Silage	3. Chaff and screenings
4. Feeds of animal origin		

All feedingstuffs are composed of a number of constituents and their classification is given below :—



The feedingstuffs available in Ceylon in appreciable quantities are coconut poonac, rice bran and paddy straw and in small quantities gingelly poonac, fish meal, the husks & screenings of a few cereals and pulses. With the development of the dry zone areas small quantities of maize, sorghum, kurakkan and some pulses are now becoming available for livestock feeding.

1. Coconut Poonac. Coconut poonac, of which about 60,000 tons are produced yearly, forms the chief source of protein in the rations for livestock. Its protein content of 21 to 25 per cent. on a moisture free basis (all figures quoted are on this basis if not otherwise stated) is low when compared with gingelly poonac with 42 per cent. and groundnut cake with 45 per cent. protein. It is however cheap and there is little variation in its composition except for the fat content which depends on the method of extraction employed. The prices offered for coconut oil being favourable the millers have endeavoured to extract as much oil as possible. The country mill or *chekku*-pressed poonac contains 14 to 16 per cent. oil, the expeller extraction reduced it to 12 to 13 per cent., the pretreated and expeller extraction reduced this still further to 6 to 7 per cent. and finally the solvent extracted poonac produced recently has only 1 per cent. oil. Coconut poonac is the main source of fat in the rations of cattle in Ceylon. Thus if the low fat or oil content poonac is to be used, the deficiency in fat will have to be made up by the addition of some oil seed, like cotton seed. It is estimated that a ration for cattle should contain at least 2.5 per cent. fat but a slightly higher fat content should prove advantageous. Rations containing as much as 70 per cent. of coconut poonac has had no adverse effect on the yield of milk of cows in our farms. It may be mentioned here that the lowering of the fat content of the poonac increases the protein to a slight degree.

2. Rice bran. The three large Government rice mills at Anuradhapura, Batticaloa and Ambalantota produce excellent rice bran with 12 to 13 per

cent. protein and 7 to 9 per cent. fibre and is free of husk. It is as good if not better than the imported Burma rice bran but unfortunately the quantity produced is small. The smaller rice hulling plants produce an inferior type of bran containing 70 to 85 per cent. husk and having a protein content of only 3 to 5 per cent. This bran due to the large amount of husk may be actually harmful to livestock and should not be fed. Good quality rice bran should contain not less than 12 per cent. protein and not more than 12 per cent. fibre. Rice bran of good quality may be fed at levels up to 40 to 45 per cent. of the concentrate ration.

3. Paddy Straw. Approximately 500,000 tons of paddy straw are produced annually and although like most straws it contains no digestible protein, still it forms a large portion of the ration of cattle. In India cattle in rice growing areas, are found to be stunted and unthrifty, while those in the wheat areas are not so. Both these straws have a similar nutritive value and the respective straws are fed at practically the same level. Indian animal nutrition workers (1) found that rice straw contained large quantities of oxalates, the major portion of which was in combination with potassium while a small but appreciable portion was in the form of calcium oxalate insoluble in the gastric juices. This small quantity of calcium oxalate could not account for the negative mineral balance. The potassium oxalate on the other hand was converted into potassium carbonate and bicarbonate in the fore stomach of cattle and interfered with the assimilation of calcium. The decomposed products cause severe alkaline symptoms or alkalosis, which either inhibits the flow of gastric juice or neutralises its effective acidity, as a result of which the solubility of calcium in the feeds, preparatory to its absorption, is adversely affected. The calcium passes out in the faeces unabsorbed leaving the animals in a deficit calcium balance. Lye treatment of straw i.e., steeping the straw in a solution of 1 per cent caustic sode for 24 hours and washing it, removes about 90 per cent. of the oxalates. The protein still remains totally indigestible but the carbohydrate fraction is increased in quantity and digestibility with a consequent increase in the total digestible nutrients. The adoption of lye treatment is not feasible under normal village conditions. Steeping the straw in water for 24 hours was next tried and they claimed that the same beneficial effects as lye treatment are obtained but to a slightly lesser degree.

A trial carried out at Peradeniya (2) with 6 Sinhala bulls to study the effect of lye treatment and water washing on the digestibility of paddy straw confirmed the beneficial effects of the lye treatment but in the water washed straw a decrease in the digestibility as against the untreated straw was observed. Significant observations during this trial were (*a*) although the animals were in a negative mineral balance they kept quite fit and showed no emaciation as shown in a trial carried out by the author (3) in India with maize husk. (*b*) There was no marked diuresis as observed by the Indian workers. This may probably be the result of cattle in Ceylon being underfed for centuries adopting a low mineral level.

Straws, though they have little or no feeding value, perform an important

function in the stomach of ruminants. They prevent the compaction of the food material in the stomach of cattle and by exposing a greater surface to the action of the enzymes and digestive fluids, bring about a more efficient digestion of the food. If paddy straw is left in the byre at night the cows will eat sufficient to make up any deficiency of dry matter. This is specially so in the case of high yielding cows.

4. Fish Meal. Fish meal is a valuable source of animal protein for feeding to all types of livestock, provided it is of good quality. Local fish meal, so lately as 1948-50, was of an extremely poor quality, as most of it was sweepings from dry fish stores. Since then the Fisheries Department in an attempt to utilize the inedible and waste fish from the fishing industry, started the manufacture of fish meal on a small scale. They turned out fishmeal with 50-55 per cent. protein which had a marked effect on the local dealers' material which improved steadily from the original 25-30 per cent. protein to excellent material with as much as 58-60 per cent. protein. But unfortunately since the last six months or so fish meal samples offered for sale were found to contain large amounts of sulphides, indicating the presence of putrified fish, which are toxic to livestock. Several of these samples were from the Fisheries Department. Good quality fish meal must have at least 60 per cent. protein and not more than 4 per cent. salt. A high fat content is not desirable as it tends to taint the milk, eggs, etc., and adversely affects the keeping quality. Further they should be free of sulphides. Fish meal should not exceed 15 per cent. of the ration of chicks and growers, 10 per cent. of layers and 7 per cent. in those of milking cows. If these amounts are exceeded the eggs, milk and even the flesh may become tainted. Fish meal is also a rich source of calcium and phosphorus.

5. Roughages. Good forage, meaning the green and dry roughages, is the foundation for efficient production for most farm animals and its use considerably reduces the expensive concentrates. Cattle and other ruminants on account of their capacious digestive tracts, are able to digest large quantities of fibrous materials, while swine and poultry can digest only small amounts of such materials.

Wright (4) points out that for the $1\frac{3}{4}$ million cattle population of the island only about 10 per cent. of their requirements can be met by home-grown feedingstuffs other than fodder and grazing. This means that the remaining 90 per cent. must be met from grazing and cut fodder, but in fact very little of the required amount can be found from this source at present. The importance of developing this source of food for livestock cannot be over emphasised.

6. **Pasture.** Good pasture is the ideal feed for livestock and it is claimed that an acre of such pasture in temperate climates can maintain from 1 to $2\frac{1}{2}$ head of cattle or provide all the nutrients required for cows yielding as much as 3 to 4 gallons of milk. This is very different from the so called grazing lands often misnamed " pastures " in Ceylon. Rich pastures in those countries, carrying about 50 per cent. legumes, usually clovers, and specially selected grasses which are quick growing and high yielding, are carefully cultivated crops. The preparation of the land and the fertilizers applied are on the same scale as for any economic crop.

The Department of Agriculture is trying out various grasses, legumes and combinations of these for different parts of the island. The grass *Brachiaria Brizantha* introduced from Kenya in 1949 is the most promising of the large number tried out. It was selected for its outstanding performance as a pasture grass at the Polonnaruwa Livestock Farm, where it kept green right throughout one of the most severe droughts experienced in that station. Over 400 acres of this grass has been grown in the Departmental farms throughout the island. This grass smothers out weeds better than any other. Molasses grass *Melinis minutflora* is a satisfactory grass for the wet low-lands and for mid country areas. Of the legumes *Stylosanthes gracilis* and *Indigofera endecaphylla* are the best. Fodder Dhal planted 6′ × 6′ in *Brachiaria brizantha* pastures gives a fair amount of legume material. Work is in progress and there is every reason to hope that pastures will play an increasingly important role in the nutrition of cattle in Ceylon.

The fodder grasses Napier, Guinea, and Mauritius are the only soiling crops grown. No legume material is fed at all. A crop of maize or sorghum together with cowpeas will be a decided improvement.

Very little use is made of hay or silage, and of the straws paddy straw is the only one used, whereas large quantities of cereal and legume straws are available but seldom or never used.

Search For New Feedingstuffs

The limited range and very often the shortage of even these few feedingstuffs has drawn the attention of livestock owners to the feasibility of utilizing waste materials from human foods and other materials not normally fed to cattle. In a search for new feeds the quantity available, the distribution and the economics of their utilization have to be considered. A number of such materials have therefore been analysed (5) as a preliminary step to ascertaining the posibility of utilizing some of these as feedingstuffs. These analytical data alone are no criterion of the actual nutritive value. Feedingstuffs of similar composition may have different nutritive values, on account of the differences in the digestibility of their constituents. Before recommending a feedingstuff, its palatability and nutritive value should be known. The material should be free of harmful effects on prolonged feeding. The nutritive value is determined by feeding the material to animals, under strictly controlled conditions and estimating the digestibility of the several constituents. Cassava tubers, jak, bread-fruit, plantain, cabbage, red-pumpkin leaves, sugar-cane tops, mango seed kernal and Ingasaman pods were analysed. Most of these are valueless as feeding stuffs and the others are not available in quantity. Sugar-cane tops have been fed to cattle at the livestock farm, Polonnaruwa.

The possibilities of utilizing the slaughter wastes from the Colombo abattoir was investigated. Approximately 33 tons of blood meal valued at Rs. 26,000 and containing 26½ tons of valuable protein can be prepared per year from this abattoir alone. Besides the blood, condemned meat, offals and carcases of dead animals from the city amount to about 65 tons. This material can be turned into meat meal or meat and bone meal, a valuable source of animal protein for feeding livestock. Meat scrap or dry rendered tankage

contains 50 to 60 per cent. proetin while meat and bone meal contains 45 to 50 per cent. protein and an additional 11 per cent. calcium and 5 per cent. phosphorus.

Computation of Rations

In computing a ration due consideration must be paid to the type of animal and the purpose for which it is kept. The differences both in size and structure of the digestive tracts of the different types of animals makes it necessary to treat each type separately. The ruminants—cattle, goats, etc. with their capacious four stomachs require a large bulk of food and are capable of utilizing large quantities of coarse materials, while on the other hand the fowl with its very simple digestive tract cannot utilize bulky fodders. The pig too has a small digestive tract with no provision for digesting coarse materials.

For convenience a ration may be divided into two main parts :—

(1) The maintenance ration being that portion of the ration which provides the nutrients required merely for living when doing no work or yielding any product. This supplies the heat to maintain the body temperature, the energy for the vital living processes like breathing, the protein and minerals necessary for the repair of waste and the essential vitamins.

(2) The second portion or the Production ration provides for growth, fattening, work, or the production of milk, eggs, wool, etc., and/or reproduction.

Animals to be healthy and productive require the right proportions of carbohydrates, fats, proteins, mineral matter, water and vitamins. The carbohydrates and fats supply the energy quota. The proteins though able to supply energy function mainly as material for the formation of new body tissue and the replacement of worn out tissue. The quality of the protein is as important as the quantity. Minerals are required for the building up and the repair of the skeletal structure and for maintaining the physiological equilibrium of the body fluids. Vitamins though required in but small quantities are essential for growth, production and reproduction.

In formulating a ration it is necessary to know the chemical composition of the feedingstuff which gives the gross amount of nutrients present in the material. But as nutrients in different feedingstuffs are not acted upon by the digestive juices to the same extent, it is even more important to know the co-efficient of digestibility or the percentage of the actual amount digested of each of the constituents. With the aid of this information the available nutrients in a feedingstuff can be assessed.

Various feeding standards have been worked out for supplying the requirements of livestock. The one most commonly used is Morrison's Feeding Standards. In these standards the digestible nutrients have been classified under two heads. (1) The portion supplying the energy is designated total digestible nutrients (T. D. N.) and (2) the digestible crude protein (D. C. P.). The T. D. N. is the sum of the digestible crude protein, digestible total carbohydrates and the digestible ether extract (fat) multiplied by 2.25. The digestible ether extract has been multiplied by 2.25 because its energy value is 2.25 times more than either of the others.

In the Morrison Feeding Standards is given the requirements of Dry Matter, D. C. P. & T. D. N. for different animals for the various purposes for which they are kept. The maintenance requirements are given according to the weight of the animal. The production requirements are given in separate tables. For milk, the requirements are for each pound of milk depending upon the percentage of fat in the milk. By referring to these tables the total requirements for any animal for any particular purpose can be ascertained and a ration computed with suitable feedingstuffs so as to provide the requirements.

Rations for Cattle

In computing a ration for cattle the appetite or the amount of food an animal is capable of eating must be considered first. This is based on the dry matter content of the ration and it is recorded that dairy cows can eat 2 to 2½ lbs. of dry matter per 100 lbs. of body weight. Instances have been reported of cows exceeding these limits but for the present these figures should be adhered to. Then within this amount of dry matter the requirements of digestible crude protein and the total digestible nutrients must be provided. Besides these, cattle require the essential minerals and vitamins. Under the conditions in Ceylon where most of the soils are deficient in calcium and phosphorus it becomes necessary to provide these minerals in the form of a mineral mixture. The other minerals necessary are sodium chloride (common salt) and a small quantity of iodine in the form of potassium iodide unless any particular deficiency is found. With regard to the vitamins, Vitamin A or Carotene and Vitamin D are the only two that need be considered in the feeding of cattle. The vitamins of the B complex are synthesised by cattle in their rumens. The Vitamin A requirements can always be met by the green fodders or pasture fed and the sun light will take care of the Vitamin D. The calcium and phosphorus requirements of cattle are given in Morrison's tables. In the case of common salt the addition of 2/5 lb. for every 100 lbs. of the concentrate mixture will satisfy the minimum requirement. It is however advisable that in addition blocks of salt be left in the dairy to which the cows have free access.

The feeds given should be palatable and the larger the amount the more palatable it should be. This may be achieved by including as many feedingstuffs as is practicable in the ration. For high yielding cows pasture or fodder alone is not sufficient, concentrates must be fed to satisfy their requirements. The concentrate portion of the ration may best be fed as a mixture of concentrates made up to a standard D. C. P. and T. D. N. content.

Appendix Table I gives the nutritive value of the commonly used feedingstuffs in Ceylon.

A series of concentrate mixtures is given in Appendix Table II. The object of giving a number of these mixtures instead of just one or two is that due to unavailability or the fluctuation in price of one or more of the feedingstuffs a change may be found necessary. Thus if for instance gingelly poonac of good quality is not available or the price is so high as to make the ration uneconomic, all that has to be done is to use a ration without this constituent. The first ration contains all the normally used feedingstuffs and balanced to 14-15 per cent.

D. C. P. and 75-80 per cent. T. D. N. The others are balanced to the same percentage of D. C. P. and T. D. N. but have one, two, or three feedingstuffs omitted. Appendix Table III gives a similar series of concentrate mixtures balanced to 16-17 per cent. D. C. P. and 75-80 per cent. T. D. N. One pound of any one of these mixtures provides the nutrients for 2½ lbs. of milk with 4 per cent. fat. The second series with a higher protein content is for use when the roughage is of poor quality so that the shortage of protein in the roughage is made up by the excess of protein in the concentrate mixture. If roughage of excellent quality like high grade pasture is available then a concentrate mixture containing even as little as 12 per cent. protein will do. But in Ceylon good grazing and cut fodder will represent only medium quality roughage and under such conditions 14-15 per cent. protein concentrate mixtures are necessary ; while when the quality of the roughage is still lower as during the dry season the concentrate mixtures with the higher protein content are necessary. If a further deterioration in the roughage takes place and there is a shortage of green material, with the result that a good deal of straw and dried grass constitute the roughage, then concentrate mixtures with as much as 19-20 per cent. protein will have to be used.

When cows are stall fed as is the normal practice in India, the computation of rations is simplified. The reason being that the total requirement can be given on a computation. But when the cows are grazed the amount eaten cannot be accurately assessed. Stall feeding however becomes uneconomic due to the expense incurred in cutting and transporting of the feed to the cows. This cost becomes prohibitive when labour is expensive, as in most progressive countries. Thus good pasture has come to stay in such countries.

Morrison's Feeding Standards for the requirements of cattle for maintenance and for various forms of production are given in Appendix II. With the information given in these tables it is possible to assess the requirements of any animal (cattle) for any particular purpose and to meet that requirement from the feedingstuffs given in Table I.

An example of a ration for a stall fed cow—a ration for a dairy cow weighing 800 lbs. and giving 15 lbs. of milk with 4 per cent. fat. The feedingstuffs available are Napier grass, paddy straw and the concentrate mixtures in Tables II and III.

	Dry matter *lb.*	*D. C. P.* *lb.*	*T. D. N.* *lb.*
Maintenance requirement for a 800 lb. cow	20	·54	6·5
For 15 lb. milk with 4 per cent. fat	—	·74	4·8
Total requirement	20	1·28	11·3
50 lb. napier grass	12·5	·40	6·3
5 lb. Mixture No. 2	4·5	·85	3·9
4 lb. paddy straw	3·6	—	1·7
	20·6	1·25	11·9

When cows are on pasture or are grazing, allowance must be made for the nutrients they get from grazing. This cannot be assessed accurately and so an approximate value must be arrived at.

A cow weighing 800 lbs. will eat 20 lbs. dry matter. If this cow is yielding 15 lbs. of milk with 4 per cent. fat, the requirements will be the same as in the case quoted above. Now an approximate value for the herbage from the type of pasture found in Ceylon (*Bracharia brizantha* or Molasses grass) will be 1.0 per cent. D. C. P. and 14 per cent. T. D. N. If the cow is given 45 lbs. of Napier grass and 4 lbs. of the concentrate mixture No. 2, the cow will get 14.9 lb. of dry matter. If it is reckoned that the balance dry matter of 5.1 lb., will be available to the cow from grazing, the cow will have to eat at least 25 lb. of pasture. This is presented below in tabular form.

	Dry matter	*D. C. P.*	*T. D. N.*
45 lb. Napier grass	11·3	·36	5·6
4 lb. Mixture No. 2	3·6	·68	3·2
25 lb. Pasture	6·3	·25	3·5
	21·2	1·29	12·3

This is diagramatically shown in Fig. I.

It will be seen that the requirements are met. On this basis in Table IV are shown rations for varying ranges of milk production.

During seasons when the cut grass and the pasture herbage become drier and coarser more concentrates will have to be fed, but when the growth is more luxuriant with abundance of new flush less concentrates will suffice and the amount of cut fodder can also be lessened. If sufficient pasture of good quality is available no cut fodder will be necessary. This can be gauged by the amount of cut fodder the cows will eat in the byres.

If the cow is able to get its full requirements of dry matter i.e. 20 lb. from the type of pasture mentioned above it will eat 80 lb. of it.

	Dry matter lb.	*D. C. P.* lb.	*T. D. N.* lb.
80 lb. pasture	20	·80	11·2

This will be sufficient for maintenance and for 5 lb. of milk with 4 per cent fat. Though this may look formidable a cow of this weight can easily eat this amount of pasture, provided the herbage is of good quality. Cows in temperate countries eat 130-150 lb. of pasture. It must be mentioned here that fodder grasses of the type of napier grass cannot be the sole feed of cows giving so much milk.

	Dry matter lb.	*D. C. P.* lb.	*T. D. N.* lb.
80 lb. Napier grass	20	·64	10·0

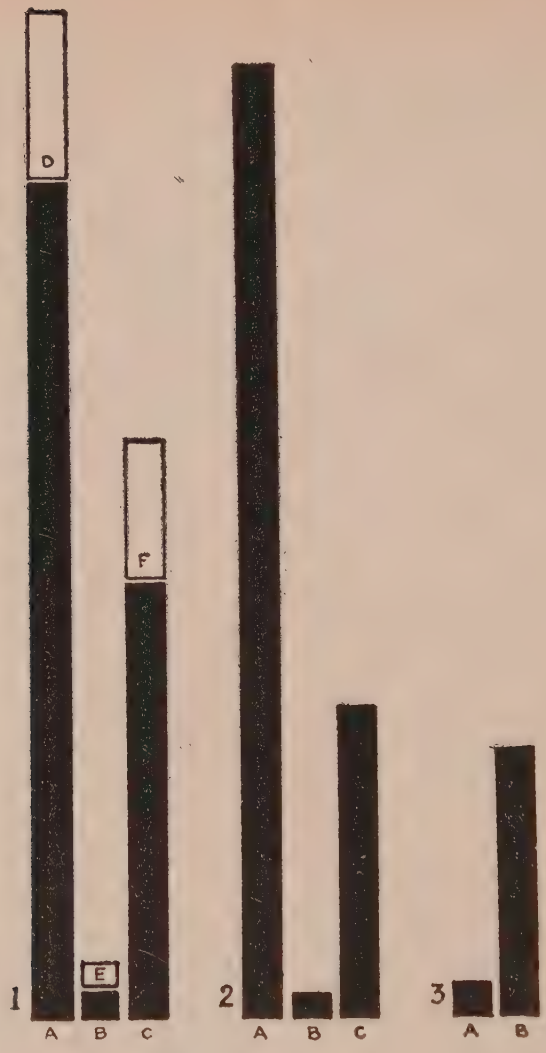


FIGURE I

1.—A .. D. M. from Roughages
D .. D. M. from Concentrates
B .. D. C. P. from Roughages
E .. D. C. P. from Concentrates
C .. T. D. N. from Roughages
I .. T. D. N. from Concentrates

2.—A .. D. M. required for Maintenance
B .. D. C. P. required for Maintenance
C .. T. D. N. required for Maintenance

3.—A .. D. C. P. left over for Milk Production
B .. T. D. N. left over for Milk Production

Besides the fact that 80 lb. of napier grass do not provide sufficient D. C. P. or T. D. N., a cow will not eat so much of this grass due to its coarseness.

Well prepared silage of good quality can replace fodder grass and may be fed at the rate of 40 to 60 lb. But hardly any silage is made in Ceylon.

A cow in calf will need an extra amount of nutrients for the development of the foetus. Therefore from about the second month before calving an additional amount of concentrates should be given over and above that provided for maintenance and milk production if the cow is still milking.

The following scheme of feeding is given for dry cows from the second month before calving.

2 months before calving			2 lb.	Concentrate mixture No. 2.				
1 month	„	„	4 „	„	„	„	„	„
2 weeks	„	„	6 „	„	„	„	„	„
1 week	„	„	8 „	„	„	„	„	„

If the udder shows congestion or the cow is constipated the ration should be cut down to about half, three days before and three days after calving.

Cows should be given a rest period by drying them if necessary at 1-2 months before calving, to enable them to build up the store of nutrients which have been drawn upon during the lactation. This period is also helpful for the development of the secreting tissues of the mamary glands before another lactation starts. Proper feeding during the dry period is necessary to get the cow in condition for the next lactation. This is known as freshening or steaming up. The feeding will therefore be according to the condition of the cow at the end of the lactation. The cow should be in fat condition at the start of the lactation.

In Fig. II, the normal lactation curve of a cow is shown as given by Maynard (6).

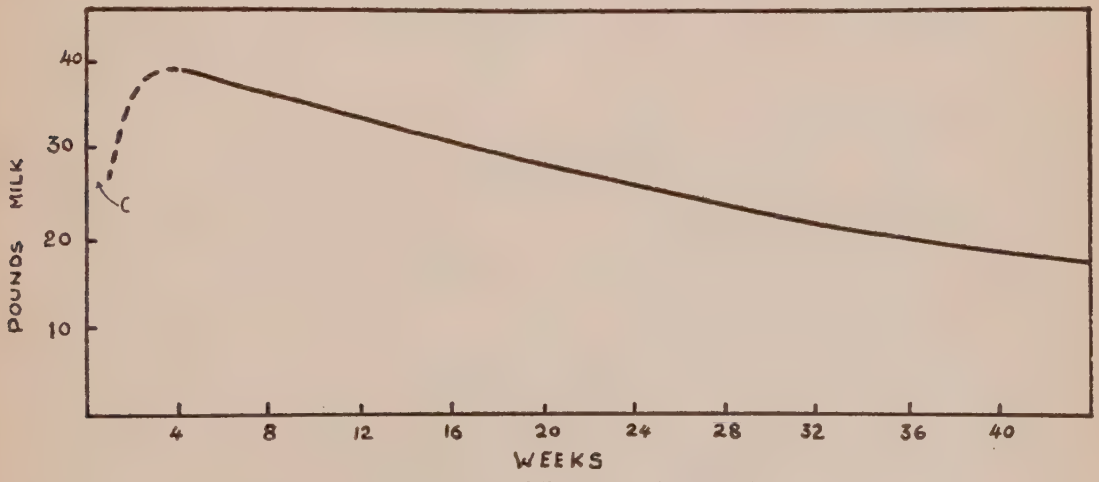


Fig. II—Lactation Curve of the Cow (not pregnant)

C Colostrum Period
- - - - Rapidly increasing milk yield governed by heredity
——— Gradually declining milk yield, governed mainly by feeding

It will be noticed that the curve rises steeply from the time of calving to one to two months and then gradually falls. The steepness of the curve is governed by heredity and the condition of the cow at the time of calving. During this period there is a tremendous urge to produce milk and in the absence of the necessary nutrition, there will be a drain from the body to provide for this requirement, with consequent ill effects. The second part of the curve is governed more by the feeding during that period and the better the feeding the more gradual the fall. During the first period overfeeding will stimulate the urge for production further and may be harmful. Cows that are overstimulated in the first stage will be found to lose weight considerably. The monthly rate of decrease in milk yield varies with individual cows and ranges between 4-9 per cent depending on their persistency of production. After the seventh month the decline is more rapid due to the effect of pregnancy. The effect is most marked after the fifth month of pregnancy.

Calf Feeding

It is very important that the calf gets the colostrum or the first milk, yielded by the cow for a short time after the birth of the calf. The colostrum differs greatly from the normal milk and is specially rich in protein and Vitamin A. The protein is largely composed of globulin which contains antibiotics or immunising substances that protect the calf against infections of the digestive system.

The longer the calf is fed on whole milk even up to six months the better will be its growth. But for economic reasons the feeding of whole milk has to be restricted. It is however advisable that the period be not less than one month and thereafter skim milk be fed together with a small amount of concentrate till the calf gets used to a concentrate and roughage ration. The changes should in all cases be made very gradually.

The requirements of cattle for growth and fattening have also been worked out but the rearing of beef cattle is hardly ever undertaken in Ceylon.

Dairy Bulls for Service

The stud bull requires less protein than the dairy cow but the feeding of unduly large quantities of dry roughage should be avoided as this tends to make them inactive.

A stud bull weighing 1,200 lb. requires 14-16 lb. of dry matter, 1.02-1.12 lb. of D. C. P. and 9.8-10.8 lb. of T. D. N. These requirements may be supplied by the following :—

	D. M. *lb.*	*D. C. P.* *lb.*	*T. D. N.* *lb.*
50 lb. Napier grass	12·5	·40	6·25
4 lb. Concentrate mixture No. 2 series ..	3·6	·68	3·2
	16·1	1·08	9·45

If good grazing is available the cut grass may be reduced to half. Unfortunately Morrison does not give the requirements for bulls weighing less than 1,200 lb.

Morrison's Feeding standards do not cover the requirements for draft cattle. Lander (7) and Sen (8) have given these requirements.

Some Nutrition Problems

The roughage is the main problem in the nutrition of cattle in Ceylon. Under the high temperature and high humidity conditions that prevail in Ceylon, there is an acceleration of fibre formation and lignification of this fibre in all plant material, with the result that the fodders and pasture components suitable to our climatic conditions are much coarser than those in temperate climates. In Ceylon a cow is unable to eat more than 50-60 lb. of fodder grasses like Napier. Even in the case of pastures that have been, up to now, successfully grown in our farms, the coarseness is apparent. In temperate climates due to the availability of good quality roughage the use of concentrates has been cut down to a minimum. But here the use of large amounts of concentrates will have to continue till such time as we are able to improve the quality of our roughages. Concentrates of good quality besides being in short supply are far too expensive for meeting any large proportion of the requirements of cattle. The amount of roughage grown in the island for cattle is extremely small and bears no relation to their requirements. Roughages in Ceylon are coarser and consequently the protein will be lower than of those in temperate climates. If however some type of pasture is available in abundance the deficiency of protein can be made up from concentrates.

With regard to the concentrates, one problem that is worth solving is the utilization of the huller mill rice bran. The one million acres of paddy land annually cropped in Ceylon will yield, at the rate of 28 bushels per acre and 46 lb. per bushel 575,000 tons of paddy. According to the milling outturn data from Burma (9) the percentage outturn of rice bran from paddy varies from 2.45 to 10.89, depending upon the degree of polishing. Even if the lowest figure of 2.45 per cent. is used the total rice bran that can be produced per year will amount to 14,087.5 tons. The three big Government mills at Ambalantota, Batticaloa and Anuradhapura produce only 600 tons. Therefore the balance of 13,487.5 tons of rice bran is from huller mills and hand pounding. If it is assumed that the 487.5 tons are produced by hand pounding the balance of 13,000 tons is from huller mills. If this 13,000 tons of rice bran was of the same quality as of that produced by the three big mills it would contain on the basis of 12 per cent. protein 1,560 tons of protein. Calculating at Rs. 200 per ton of rice bran it will work out Rs. 2,600,000. But unfortunately due to the high content of husk in huller mill bran it is not suitable for feeding to livestock. Thus 13,000 tons of rice bran valued at Rs. 2,600,000 goes to waste at present and we are compelled to import rice bran from Burma. If we are able to reclaim and utilize this large amount of rice bran we would be self-supporting in this commodity and prevent money going out of the country.

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APPENDIX I

Table 1

Feedingstuffs	*Dry Matter Per cent*	*D. C. P. Per cent*	*T. D. N. Per cent*
Oil cakes			
Coconut poonac	90	18	78
Gingelly poonac	90	34	70
Cereals			
Maize	—	—	—
Sorghum	90	7	80
Kurakkan	—	—	—
Pulses			
Gram	—	—	—
Green gram	90	19	76
Cowpea	—	—	—
Milling by-products			
Rice bran	90	7	67
Oil seeds			
Cotton seed	90	17	91
Animal proteins			
Fish meal	90	46	72
Fodder grasses			
Napier grass	25	0·8	12·5
Guinea grass	—	—	—
Pasture, mainly grasses like Mollasses and *Brachiaria brizantha*	25	1·0	14·0

Note.—For purposes of rationing the dry matter content of the various feedingstuffs are taken as follows :—

Cereals, pulses, oil seed, oil cakes, brans, &c.	90% D. M.
Fodder grasses, pasture	25% D. M.
Silage and fodder crops at a tender stage of growth	35% D. M.

The figures for D. M., D. C. P. and T. D. N. are the whole numbers of the averages for the different feedingstuffs.

TABLE 2

To every 100 lb. of each one of the concentrate mixtures given in the tables, two lb. of the following mineral mixture should be added :—

Mineral mixture —

Sterilized bone meal or flour	.. 50 lb.
Ground limestone	.. 30 lb.
Common salt	.. 20 lb.
Potassium iodide	.. 1 oz.
	100 lb., 1 oz.

Concentrate mixtures series No. 1.– All balanced to 14 15 per cent. digestible crude protein and 75 80 per cent. total digestible nutrients.

TABLE 2 A

RATIONS WITH ALL THE COMPONENTS AND ONE ELIMINATED SUCCESSIVELY

Feedingstuffs	*Total* lb.	*D.C.P.* lb.	*T.D.N.* lb.	*Price* Rs. c.	*Total* lb.	*D.C.P.* lb.	*T.D.N.* lb.	*Price* Rs. c.	*Total* lb.	*D.C.P.* lb.	*T.D.N.* lb.	*Price* Rs. c.	*Total* lb.	*D.C.P.* lb.	*T.D.N.* lb.	*Price* Rs. c.
Coconut poonac	25	4·50	19·50	2 50	30	5·40	23·40	3 0	25	4·50	19·50	2 50	35	6·30	27·30	3 50
Gingelly poonac	5	1·70	3·50	1 35	no gingelly poonac				5	1·70	3·50	1 35	5	1·70	3·50	1 35
Pulses	5	0·95	3·80	1 15	5	0·95	3·80	1 15	no pulses				5	0·95	3·80	1 15
Cereals	40	2·80	32·00	4 0	35	2·45	28·00	3 50	35	2·45	28·00	3 50	no cereals			
Rice bran	10	0·70	6·70	0 90	10	0·70	6·70	0 90	15	1·05	10·05	1 35	40	2·80	26·80	3 60
Fish meal	5	2·30	3·60	1 34	5	2·30	3·60	1 34	5	2·30	3·60	1 34	5	2·30	3·60	1 34
Cotton seed	10	1·70	9·10	1 0	15	2·55	13·65	1 50	15	2·55	13·65	1 50	10	1·70	9·10	1 0
	100	14·65	78·20	12 24	100	14·35	79·15	11 39	100	14·55	78·30	11 54	100	15·75	74·10	11 94
Coconut poonac	25	4·50	19·50	2 50	30	5·40	23·40	3 0	30	5·40	23·40	3 0				
Gingelly poonac	5	1·70	3·50	1 35	5	1·70	3·50	1 35	10	3·40	7·00	2 70				
Pulses	5	0·95	3·80	1 15	5	0·95	3·80	1 15	5	0·95	3·80	1 15				
Cereals	50	3·50	40·00	5 0	40	2·80	32·00	4 0	40	2·80	32·00	4 0				
Rice bran	no rice bran				5	0·35	3·35	0 45	10	0·70	6·70	0 90				
Fish meal	5	2·30	3·60	1 34	no fish meal				5	2·30	3·60	1 34				
Cotton seed	10	1·70	9·10	1 0	15	2·55	13·65	1 50	no cotton seed							
	100	14·65	79·50	12 34	100	13·85	79·70	11 45	100	15·55	76·50	13 9				

TABLE 2B

Concentrate mixture series No 1.– A'l balanced to 14–15 per cent. digestible crude protein and 75 80 per cent. total digestible nutrients

RATIONS WITH TWO COMPONENTS ELIMINATED SUCCESSIVELY

Feedingstuffs	*Total lb.*	*D.C.P. lb.*	*T.D.N. lb.*	*Price Rs. c.*	*Total lb.*	*D.C.P. lb.*	*T.D.N. lb.*	*Price Rs. c.*	*Total lb.*	*D.C.P. lb.*	*T.D.N. lb.*	*Price Rs. c.*	*Total lb.*	*D.C.P. lb.*	*T.D.N. lb.*	*Price Rs. c.*
Coconut poonac	35	6·30	27·30	3·50	40	7·20	31·20	4·00	40	7·20	31·20	4·00	45	8·10	35·10	4·50
Gingelly poonac	no gingelly poonac				no gingelly poonac				no gingelly poonac				no gingelly poonac			
Pulses	no pulses				5	0·95	3·80	1·15	5	0·95	3·80	1·15	5	0·95	3·80	1·15
Cereals	35	2·45	28·00	3 50	no cereals				40	2·80	32·00	4 0	30	2·10	24·00	3 0
Rice bran	10	0·70	6·70	0 90	40	2·80	26·80	3 60	no rice bran				10	0·70	6·70	0 90
Fish meal	5	2·30	3·60	1 34	5	2·30	3·60	1 34	5	2·30	3·60	1 34	no fish meal			
Cotton seed	15	2·55	13·65	1 50	10	1·70	9·10	1 0	10	1·70	9·10	1 0	10	1·70	9·10	1 0
	100	14·30	79·25	10 74	100	14·95	74·50	11 09	100	14·95	79·70	11 09	100	13·55	78·70	10 55
Coconut poonac	45	8·10	35·10	4 50	40	7·20	31·20	4 0	40	7·20	31·20	4 0	50	9·00	39·00	5 0
Gingelly poonac	no gingelly poonac				5	1·70	3·50	1 35	5	1·70	3·50	1 35	5	1·70	3·50	1 35
Pulses	5	0·95	3·80	1 15	no pulses				no pulses				no pulses			
Cereals	35	2·45	28·00	3 50	no cereals				45	3·15	36·00	4 50	20	1·40	16·00	2 0
Rice bran	10	0·70	6·70	0 90	45	3·15	30·15	4 5	no rice bran				10	0·70	6·70	0 90
Fish meal	5	2·30	3·60	1 34	5	2·30	3·60	1 34	5	2·30	3·60	1 34	no fish meal			
Cotton seed	no cotton seed				5	0·85	4·55	0 50	5	0·85	4·55	0 50	15	2·55	13·65	1 50
	100	14·50	77·20	11 39	100	15·20	73·00	11 24	100	15·20	78·85	11 69	100	15·35	78·85	10 75
Coconut poonac	40	7·20	31·20	4 0	45	8·10	35·10	4 50	40	7·20	31·20	4 0	45	8·10	35·10	4 50
Gingelly poonac	5	1·70	3·50	1 35	5	1·70	3·50	1 35	5	1·70	3·50	1 35	5	1·70	3·50	1 35
Pulses	no pulses				5	0·95	3·80	1 15	5	0·95	3·80	1 15	5	0·95	3·80	1 15
Cereals	40	2·80	32·00	4 0	no cereals				no cereals				30	2·10	24·00	3 0
Rice bran	10	0·70	6·70	0 90	30	2·10	20·10	2 70	45	3·15	30·15	4 5	no rice bran			
Fish meal	5	2·30	3·60	1 34	no fish meal				5	2·30	3·60	1 34	no fish meal			
Cotton seed	no cotton seed				15	2·55	13·65	1 50	no cotton seed				15	2·55	13·65	1 50
	100	14·70	77·00	11 59	100	15·40	76·15	11 20	100	15·30	72·25	11 89	100	15·40	80·05	11 50
Coconut poonac	45	8·10	35·10	4 50	50	9·00	39·00	5 0								
Gingelly poonac	5	1·70	3·50	1 35	10	3·40	7·00	2 70								
Pulses	5	0·95	3·80	1 15	10	1·90	7·60	2 30								
Cereals	40	2·80	32·00	4 0	20	1·40	16·00	2 0								
Rice bran	no rice bran				10	0·70	6·70	0 90								
Fish meal	5	2·30	3·60	1 34	no fish meal											
Cotton seed	no cotton seed				no cotton seed											
	100	15·85	78·00	12 34	100	16·40	76·30	12 90								

Note.—Pulses include Green Gram and Cowpea, Cereals include Maize, Sorghum. At high levels maize is preferred failing this a mixture of the two is better than sorghum alone.

D. C. P. is digestible crude protein, T. D. N. is total digestible nutrients.

TABLE 2c

Concentrate mixture series No. 1.—All balanced to 14–15 per cent. digestible crude protein and 75–80 per cent. total digestible nutrients

RATIONS WITH MORE THAN TWO COMPONENTS ELIMINATED

Feedingstuffs	*Total lb.*	*D.C.P. lb.*	*T.D.N. lb.*	*Price Rs. c.*	*Total lb.*	*D.C.P. lb.*	*T.D.N. lb.*	*Price Rs. c.*	*Total lb.*	*D.C.P. lb.*	*T.D.N. lb.*	*Price Rs. c.*	*Total lb.*	*D.C.P. lb.*	*T.D.N. lb.*	*Price Rs. c.*
Coconut poonac	40	7·20	31·20	4 0	55	9·90	42·90	5 50	55	9·90	42·90	5 50	55	9·90	42·90	5 50
Gingelly poonac		no gingelly poonac				no gingelly poonac				no gingelly poonac				no gingelly poonac		
Pulses		no pulses				no pulses				no pulses				no pulses		
Cereals		no cereals			15	1·05	12·00	1 50		no cereals			40	2·80	32·00	4 0
Rice bran	40	2·80	26·80	3 60	25	1·75	16·75	2 25	40	2·80	26·80	3 60		no rice bran		
Fish meal	5	2·30	3·60	1 34	5	2·30	3·60	1 34	5	2·30	3·60	1 34	5	2·30	3·60	1 34
Cotton seed	15	2·55	13·65	1 50		no cotton seed				no cotton seed				no cotton seed		
	100	14·85	75·25	10 44	100	15·00	75·25	10 59	100	15·00	73·30	10 44	100	15·00	78·50	10 84

TABLE III

To every 100 lb. of each one of the concentrate mixtures given below add 2 lb. of the mineral mixture given in Table II.

Concentrate mixture series No. 2.—All balanced to 16 17 per cent. digestible crude protein and 75–80 per cent. total digestible nutrients

TABLE 3A.—RATIONS WITH ALL COMPONENTS AND ONE ELIMINATED SUCCESSIVELY

Feedingstuffs	*Total lb.*	*D.C.P. lb.*	*T.D.N. lb.*	*Price Rs. c.*	*Total lb.*	*D.C.P. lb.*	*T.D.N. lb.*	*Price Rs. c.*	*Total lb.*	*D.C.P. lb.*	*T.D.N. lb.*	*Price Rs. c.*	*Total lb.*	*D.C.P. lb.*	*T.D.N. lb.*	*Price Rs. c.*
Coconut poonac	40	7·20	31·20	4 0	45	8·10	35·10	4 50	45	8·10	35·10	4 50	35	6·30	27·30	3 50
Gingelly poonac	5	1·70	3·50	1 35		no gingelly poonac			5	1·70	3·50	1 35	5	1·70	3·50	1 35
Pulses	5	0·95	3·80	1 15	5	0·95	3·80	1 15		no pulses			5	0·95	3·80	1 15
Cereals	30	2·10	24·00	3 0	25	1·75	20·00	2 50	25	1·75	20·00	2 50		no cereals		
Rice bran	10	0·70	6·70	0 90	10	0·70	6·70	0 90	15	1·05	10·05	1 35	35	2·45	23·45	3 15
Fish meal	5	2·30	3·60	1 34	5	2·30	3·60	1 34	5	2·30	3·60	1 34	5	2·30	3·60	1 34
Cotton seed	5	0·85	4·55	0 50	10	1·70	9·10	1 0	5	0·85	4·55	0 50	15	2·55	13·65	1 50
	100	15·80	77·35	12 24	100	15·50	78·30	11 39	100	15·75	76·80	11 54	100	16·25	75·30	11 99

Coconut poonac	45	8·10	35·10	4 50	45	8·10	35·10	4 50	45	8·10	35·10	4 50				
Gingelly poonac	5	1·70	3·50	1 35	10	3·40	7·00	2 70	5	1·70	3·50	1 35				
Pulses	10	1·90	7·60	2 30	5	0·95	3·80	1 15	5	0·95	3·80	1 15				
Cereals	30	2·10	24·00	3 0	20	1·40	16·00	2 0	25	1·75	20·00	2 50				
Rice bran		no rice bran			10	0·70	6·70	0 90	15	1·05	10·05	1 35				
Fish meal	5	2·30	3·60	1 35		no fish meal			5	2·30	3·60	1 34				
Cotton seed	5	0·85	4·55	0 50	10	1·70	9·10	1 0		no cotton seed						
	100	16·95	78·35	12 99	100	16·25	77·70	12 25	100	15·85	76·05	12 19				

TABLE 3B

Concentrate mixture series No. 2.—All balanced to 16–17 per cent. digestible crude protein and 75–80 per cent. total digestible nutrients

RATIONS WITH 2 COMPONENTS ELIMINATED SUCCESSIVELY

Feedingstuffs	*Total lb.*	*D.C.P. lb.*	*T.D.N. lb.*	*Price Rs. c.*	*Total lb.*	*D.C.P. lb.*	*T.D.N. lb.*	*Price Rs. c.*	*Total lb.*	*D.C.P. lb.*	*T.D.N. lb.*	*Price Rs. c.*	*Total lb.*	*D.C.P. lb.*	*T.D.N lb.*	*Price Rs. c.*
Coconut poonac	50	9·00	39·00	5 0	50	9·00	39·00	5 0	45	8·10	35·10	4 50	55	9·90	42·90	5 50
Gingelly poonac	no gingelly poonac				no gingelly poonac				no gingelly poonac				no gingelly poonac			
Pulses	no pulses				5	0·95	3·80	1 15	5	0·95	3·80	15	10	1·90	7·60	2 30
Cereals	20	1·40	16·00	2 0	no cereals				30	2·10	24·00	3 0	10	0·70	8·00	1 0
Rice bran	10	0·70	6·70	0 90	25	1·75	16·75	2 25	no rice bran				10	0·70	6·70	0 90
Fish meal	5	2·30	3·60	1 34	5	2·30	3·60	1 34	5	2·30	3·60	1 34	no fish meal			
Cotton seed	15	2·55	13·65	1 50	15	2·55	13·65	1 50	15	2·55	13·65	1 50	15	2·55	13·65	1 50
	100	15·95	78·95	10 74	100	16·55	76·80	11 24	100	16·00	80·15	11 49	100	15·75	78·85	11 20
Coconut poonac	55	9·90	42·90	5 50	45	8·10	35·10	4 50	40	7·20	31·20	4 0	50	9·00	39·00	5 0
Gingelly poonac	no gingelly poonac				5	1·70	3·50	1 35	5	1·70	3·50	1 35	10	3·40	7·00	2 70
Pulses	5	0·95	3·80	1 15	no pulses				no pulses				no pulses			
Cereals	25	1·75	20·00	2 50	no cereals				40	2·80	32·00	4 0	15	1·05	12·00	1 50
Rice bran	10	0·70	6·70	0 90	30	2·10	24·00	2 70	no rice bran				10	0·70	6·70	0 90
Fish meal	5	2·30	3·60	1 34	5	2·30	3·60	1 34	5	2·30	3·60	1 34	no fish meal			
Cotton seed	no cotton seed				15	2·55	13·65	1 50	10	1·70	9·10	1 01	15	2·55	13·65	1 50
	100	15·60	77·00	11 39	100	16·75	79·85	11 39	100	15·70	79·40	11 69	100	16·70	78·35	11 60
Coconut poonac	50	9·00	39·00	5 0	50	90·00	39·00	5 0	50	9·00	39·00	5 00	45	8·10	35·10	4 50
Gingelly poonac	5	1·70	3·50	1 35	5	1·70	3·50	1 35	5	1·70	3·50	1 35	5	1·70	3·50	1 35
Pulses	no pulses				5	0·95	3·80	1 15	5	0·95	3·80	1 15	10	1·90	7·60	2 30
Cereals	30	2·10	24·00	3 0	no cereals				no cereals				25	1·75	20·00	2 50
Rice bran	10	0·70	6·70	0 90	25	1·75	21·00	2 25	35	2·45	23·40	3 15	no rice bran			
Fish meal	5	2·30	3·60	1 34	no fish meal				5	2·30	3·60	1 34	no fish meal			
Cotton seed	no cotton seed				15	2·55	13·65	1 50	no cotton seed				15	2·55	13·65	1 50
	100	15·80	76·80	11 59	100	15·95	80·95	11 25	100	16·40	73·30	11 99	100	16·00	79·85	12 15

TABLE 3C

Concentrate mixture series No. 2.—All balanced to 16–17 per cent. digestible crude protein and 75–80 per cent. total digestible nutrients

RATIONS WITH MORE THAN TWO COMPONENTS ELIMINATED

Feedingstuffs	*Total lb.*	*D.C.P. lb.*	*T.D.N. lb.*	*Price Rs. c.*	*Total lb.*	*D.C.P. lb.*	*T.D.N. lb.*	*Price. Rs. c.*	*Total lb.*	*D.C.P. lb.*	*T.D.N. lb.*	*Price Rs. c.*	*Total lb.*	*D.C.P. lb.*	*T.D.N. lb.*	*Price Rs. c.*
Coconut poonac	50	9·00	39·00	5 0	50	9·00	39·00	5 0	55	9·90	42·90	5 50	70	12·60	54·60	7 0
Gingelly poonac	no gingelly poonac				no gingelly poonac				no gingelly poonac				no gingelly poonac			
Pulses	no pulses				no pulses				no pulses				no pulses			
Cereals	no cereals				30	2·10	24·00	3 0	no cereals				no cereals			
Rice bran	30	2·10	20·10	2 70	no rice bran				38	2·66	25·46	3 42	25	1·75	16·75	2 25
Fish meal	5	2·30	3·60	1 34	5	2·30	3·60	1 34	7	3·22	5·04	1 88	5	2·30	3·60	1 34
Cotton seed	15	2·55	13·65	1 50	15	2·55	13·65	1 50	no cotton seed				no cotton seed			
	100	15·95	76·35	10 54	100	15·95	80·25	10 84	100	15·78	73·40	10 80	100	16·65	74·95	10 59

TABLE 4

	D.M.	*D.C.P.*	*T.D.N.*
	lb.	*lb.*	*lb.*
Maintenance requirement for a 800 lb. cow	20 ..	0·54 ..	6·50
Production requirement for every lb. of milk with 4 per cent. fat ..	— ..	0·049 ..	0·32

Napier Grazing grass		*Concentrate mixture series No. 2 Total nutrients*							*Balance left for Milk*				*Sufficient for milk with 4 per cent. fat*
		D.M.	*D.C.P.*	*T.D.N.*	*Total*	*D.M.*	*D.C.P.*	*T.D.N.*	*D.M.*	*D.C.P.*	*T.D.N.*	*D.C.P.*	*T.D.N.*	
lb.	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*
50 ..	25 ..	18·75..	0·65..	9·75..	1 ..	0·9 ..	0·17..	0·75..	19·65..	0·82..	10·50..	0·28..	4·05..	5
50 ..	25 ..	18·75..	0·65..	9·75..	2 ..	1·8 ..	0·34..	1·50..	20·55..	0·99..	11·25..	0·45..	4·75..	10
50 ..	25 ..	18·75..	0·65..	9·75..	3 ..	2·7 ..	0·51..	2·25..	21·45..	1·16..	12·15..	0·62..	5·65..	12½
45 ..	25 ..	17·50..	0·61..	9·13..	4 ..	3·6 ..	0·68..	3·00..	21·10..	1·29..	12·13..	0·75..	5·63..	15
40 ..	30 ..	17·50..	0·62..	9·20..	5 ..	4·5 ..	0·85..	3·75..	22·00..	1·47..	12·95..	0·93..	6·45..	20
35 ..	30 ..	16·25..	0·58..	8·58..	6 ..	5·4 ..	1·02..	4·50..	21·65..	1·60..	13·08..	1·06..	6·56..	22½
30 ..	35 ..	16·25..	0·79..	8·65..	7 ..	6·3 ..	1·19..	5·25..	22·55..	1·98..	13·90..	1·44..	7·40..	25

Note.—D.M.—Dry matter ; D.C.P.—Digestible crude protein ; T.D.N.—Total digestible nutrients.

APPENDIX II

Feeding Standards

(Taken from "Feeds and Feeding" by F. B. Morrison. *The Morrison Publishing Co., Ithaca, New York.*)

Maintenance per head per day

Weight of cow lb.	*D. C. P.* lb.	*T. D. N.* lb.
700	·44–·48	5·1–5·8
700	·47–·51	5·4–6·2
800	·49–·54	5·8–6·5
850	·52–·56	6·1–6·9
900	·55–·59	6·4–7·2
950	·57–·62	6·7–7·6
1,000	·60–·65	7·0–7·9
1,050	·63–·68	7·3–8·3
1,100	·65–·71	7·6–8·6
1,150	·68–·73	7·9–9·0
1,200	·70–·76	8·2–9·3

For Milk Production per lp. of milk

(In addition to the maintenance allowance)

Per cent fat in milk	*D. C. P.* lb.	*T. D. N.* lb.
3.0	.036–.043	.26–.28
3.5	.038–.046	.28–.30
4.0	.041–.049	.31–.32
4.5	.044–.052	.33–.35
5.0	.046–.056	.35–.37

For Pregnancy

(In addition to the allowances for maintenance and for milk)

	D. C. P. lb.	*T. D. N.* lb.
Small cow	.50–.55	5.0–5.5
1,000 lb. cow	.55–.60	5.5–6.0
Large cow	.65–.70	6.5–7.0

DEPARTMENTAL NOTES

Fertilizer Recommendations for Rice

RECENT ADVANCES in our knowledge of the physiology of the rice plant and the chemistry of rice soils suggest that the departmental recommendations for the fertilization of rice contained in your No. AR. 651 of April 19, 1950, require considerable modification.

2. There is sufficient evidence now to indicate that: (i) the bulk of the phosphate utilized by the rice plant is accumulated during the early stages of growth;

(ii) maximum assimilation of nitrogen takes place at two critical stages in the life of the rice plant, namely, at tillering and at the time of ear primordia initiation (2-4 weeks before heading);

(iii) ammonium sulphate is undesirable on soils low in iron.

3. There is also theoretical evidence, supported by some local experiments, that the form of phosphatic fertilizer is relatively unimportant in the case of lowland rice, except perhaps on the slightly alkaline and alkaline soils of the dry zone.

4. It follows from the above principles that: (i) phosphate should be applied at or before planting;

(ii) rock phosphates (the cheapest form) are almost as good as the much more expensive superphosphate, at least for wet zone soils;

(iii) nitrogen should be applied in split doses: hence the nitrogenous fertilizer should be available to the cultivator unmixed with other fertilizers;

(iv) ammonium sulphate should be avoided on soils low in iron such as white sandy soils and "kirimatta" soils.

5. Fertilizer experiments in cultivators fields are now in progress and island-wide experiments are planned in the next season. Pending the outcome of these investigations it is suggested that the following fertilizer practices be adopted:—

WET ZONE

Normal Soils

Basal dressing	50 lb. ammonium sulphate 100 lb. saphos phosphate 50 lb. muriate of potash	per acre just before second ploughing
Top dressing	100 lb. ammonium sulphate per acre 30 days before heading	

(On very fertile soils ammonium sulphate may be omitted from the basal dressing)

Sandy, Peaty, and "Kirimatta" soils

Basal dressing	22 lb. urea 100 lb. saphos phosphate 100 lb. muriate of potash	per acre just before second ploughing
Top dressing	44 lb. urea per acre 30 days before heading	

DRY ZONE

Basal dressing	70 lb. ammonium sulphate 80 lb. conc. superphosphate 50 lb. muriate of potash (only on sandy soils)	per acre just before 2nd ploughing
Top dressing	140 lb. ammonium sulphate per acre 30 days before heading	

Notes: It is undesirable to mix and store ammonium sulphate or urea, saphos phosphate and muriate of potash. These fertilizers should be purchased separately.

2. Urea is hygroscopic. The fertilizer firms should be advised to market it in small plastic-lined bags holding 28 or 56 lbs.

3. Substitution of saphos phosphate for superphosphate will lead to a some saving in costs.

4. Experienced cultivators have a remarkable ability to identify fertilizers by their feel, appearance and taste. Hence the multiplicity of fertilizers will not lead to confusion in their use.

F. N. PONNAMPERUMA,
Chemist.

BOOK REVIEW

Chromosome Atlas of Flowering Plants—by C. D. Darlington and A. P. Wylie.

XIX 519 pp., George Allen and Unwin, London, 1955 : Price 60sh.

THE CHROMOSOME ATLAS OF FLOWERING PLANTS is an extension of the Chromosome Atlas of Cultivated Plants by Darlington and Janaki Ammal which appeared about 10 years ago. During this period many more plants have been studied and the work reviewed contains the chromosome numbers, basic and somatic, of nearly twenty thousand species.

The problem of the systematist is the recognition of species and for this it is necessary to know the range of variation. Morphological differences alone are misleading. Heritable changes can be detected by studying the chromosomes. Recent studies have indicated the frequent occurence of two types of chromosomes, those which " maintain heredity " and those which " stimulate variation ". The authors believe that " exploring this distinction " will be a fruitful field of research for the cytologist. Further chromosome numbers will give information as to which species are likely to give viable hybrids. Hence the information provided in the Chromosome Atlas would be of much help also to the plant breeders.

The authors have followed Hutchinson's Classification and 241 of the families are represented. These are arranged in 25 groups (gymnosperms 1, dicotyledons 18 and monocotyledons 6). Each group contains a number of families and for each family the atlas is arranged in six columns. In the first is given the name of the genus and the basic number of chromosomes. Below the genus are given the names of the species, with the synonyms within brackets. The second column gives the popular names, the third column the somatic number of chromosomes, the fourth the names and dates of the authors, the fifth the uses and sixth the distribution of the species.

There is a very extensive bibliography running to nearly 50 pages and an index to families and genera.

The printing is extremely clear and the get up attractive.

B. L. T. DE S.

METEOROLOGICAL REPORT

July-September, 1956

SUMMARY

ALTHOUGH MONSOON weather prevailed during July, the winds were again exceptionally dry. Consequently, the rainfall was considerably below normal in the south-western parts. In the south-western mid-country, comprising Matugama—Yatiyantota—Ratnapura area, at several stations with long records, the rainfall last month was the lowest on record for July. The most striking among them was 2.25 inches at Ratnapura, which was the lowest July total in 88 years, the previous lowest being 3.06 inches in 1930. Similarly, 1.48 inches at Labugama was the lowest in 78 years and 1.38 inches at Dunedin Estate (Yatiyantota) the lowest in 74 years. The resulting drought conditions are acute in these regions, as July is the third successive month with deficient rainfall. During this period (May to July) this region receives normally over 50 inches of rain, but the actual amount received this year was less than half the average. Thus, the total registered at Labugama was only 25.40 inches, as against an average of 52.61, and that at Avissawella 23.43 inches against 50.72. The bigger monthly totals during July (which occurred in the south-western hill-country) ranged from 10 to 15 inches only. From this region there was a rapid decrease in rainfall, monthly totals over a large part of the Island, including a good portion of the south-west quarter, being less than 2 inches. There was, however, a slight increase in Trincomalee District, and in the northern parts of Batticaloa District on account of evening thunderstorms that occurred between the 16th and 24th. About 80 stations in the north-western, north-central and south-eastern parts received no rain at all. Rainfall deficits in the south-western hill-country were of the order of 15 inches, while elsewhere in the south-western parts they ranged from 5 to 10 inches. Rainfall was above normal in the north-eastern coastal regions and in parts of Jaffna Peninsula. A hailstorm was reported from Haputale on the 16th.

Ordinary monsoon weather prevailed over the Island during August. The rainfall was however, chiefly confined to the southern half of the south-west quarter, where in the hill-country, rainfall was experienced practically every day several stations recording monthly totals over 20 inches. The highest totals were 35.94 inches at Maliboda Estate (Deraniyagala) and 32.24 inches at Kenilworth Estate (Ginigathena). From this region the rainfall decreased rapidly, monthly totals outside the south-west quarter being generally below 2 inches. There was an increase again in Uva and Eastern Provinces, where the aggregates at several stations exceeded 5 inches. This rainfall occurred as evening thundershowers on days when the monsoon gradient was weak. Rainfall was least in Puttalam and Mannar Districts and in Jaffna Peninsula, about 40 stations sending in nil reports. Rainfall was appreciably above normal in the southern parts of the south-west quarter, and in places in the Eastern Province, the greater excesses ranging generally from 5 to 10 inches. It was generally below normal in the western and north-western parts and in the north-eastern hill-country.

Monsoon weather prevailed during September too, with rainfall mainly confined to the south-western parts. There was however only one day (9th) on which the rainfall was appreciably heavy, when a number of stations recorded amounts over 3 inches. Towards the end of the month the monsoon gradient weakened, resulting in evening thundershowers on a few days in the eastern and north-eastern parts and among the Uva Hills. The weather was dry over the whole Island on the 15th and from 18th to 20th.

Greater monthly totals of rainfall (of the order of 20 to 30 inches) occurred in the south-western foot-hills and neighbourhood, the greatest total being 32.33 inches at Maliboda Estate (Deraniyagala). From this region the rainfall decreased gradually towards the west, monthly totals at the coastal stations being of the order of 5 to 6 inches. Outside the south-west quarter the rainfall was below 2 inches, except among the Uva Hills and, in places, in the Eastern Province, where it ranged from 2 to 5 inches.

About 50 stations in the north-central and north-western parts received no rain at all. The rainfall was below normal over a large part of the Island, deficits at many stations ranging from 2 to 5 inches. Excesses occurred in the south-western mid-country and in the neighbourhood of Batticaloa and Trincomalee.

D. T. E. DASSANAYAKE,
Director.

Department of Meteorology,
Bullers Road, Colombo 7.

	July									August			
	Temperature				Humidity		Rainfall			Temperature			
	Mean Maximum	Offset	Mean Minimum	Offset	Day	Night (from Min. Temps.)	Total	Offset	No. of Days	Mean Maximum	Offset	Mean Minimum	Offset
Anuradhapura ..	93·2	+2·4	75·3	—0·5	58	86	0·49	—0·83	2	92·2	+0·8	75·3	—0·2
Badulla ..	86·9	+0·7	64·2	—0·1	59	91	0·82	—1·35	3	86·1	+0·1	63·6	—0·9
Batticaloa	90·8	—1·1	76·2	—0·7	64	77	5·09	+4·05	7	89·8	—0·6	75·7	—0·8
Colombo ..	84·2	—0·5	76·7	—0·2	74	86	0·43	—5·06	6	84·6	—0·3	76·2	—0·8
Diyatalawa	77·8	—0·1	61·8	—0·7	61	81	1·06	—0·90	11	77·6	—0·3	61·1	—0·6
Galle ..	81·5	—1·2	75·8	—0·9	85	91	2·19	—4·15	13	80·9	—1·7	75·1	—1·7
Hambantota	87·7	+0·5	76·2	—0·1	72	86	0·19	—1·82	1	83·6	—3·4	74·6	—1·6
Jaffna ..	86·3	+0·2	79·3	—0·5	76	80	0·11	—0·44	4	84·9	—1·2	78·8	—0·5
Kandy ..	81·2	+0·1	70·0	+0·2	68	80	1·61	—4·28	16	80·2	—2·0	68·9	—0·9
Kankesanturai	89·8	—0·1	78·4	—0·8	67	82	0·80	+0·26	4	89·8	—0·3	78·5	—0·6
Kurunegala	86·3	0	75·6	+0·4	70	86	0·72	—3·16	10	86·5	—0·4	75·1	+0·2
Mannar ..	86·5	—0·9	78·4	—0·7	75	82	0·06	—0·29	3	85·8	—1·6	78·2	—0·5
Nuwara Eliya	65·5	+0·2	54·8	—0·1	81	85	5·62	—5·40	21	64·5	—1·6	54·8	+0·4
Puttalam	87·2	+1·1	77·0	—1·3	69	84	0	—0·99	0	87·5	+0·9	77·3	—0·6
Ratmalana	85·2	+0·6	75·3	—1·1	71	91	0·87	—4·59	8	84·7	—0·5	76·6	—0·8
Ratnapura	87·2	+0·6	74·0	—0·4	72	90	2·25	—10·52	27	86·1	—0·7	73·4	—0·8
Talawakele	68·6	+1·6	58·7	—0·8	87	97	6·70	—	22	67·5	—3·5	58·0	—1·2
Trincomalee	92·7	+0·3	77·4	—1·2	60	78	3·78	+2·05	8	92·5	+0·4	77·4	+0·1

	August—(contd.)					September								
	Humidity		Rainfall			Temperature				Humidity		Rainfall		
	Day	Night (from Min. Temps.)	Total	Offset	No. of Days	Mean Maximum	Offset	Mean Minimum	Offset	Day	Night (from Min. Temps.)	Total	Offset	No. of Days
Anuradhapura ..	67	86	0·45	—1·17	3	92·6	+0·8	75·1	+0·1	56	86	0	—3·76	0
Badulla ..	64	91	4·52	+1·32	9	85·9	+0·3	64·1	—0·2	61	91	1·64	—2·85	3
Batticaloa	67	79	3·65	+1·70	8	88·4	+1·3	75·6	—0·6	69	82	5·37	+2·98	6
Colombo ..	77	88	3·45	—0·58	11	83·9	—1·5	76·3	—0·2	79	88	8·66	+1·82	22
Diyatalawa	65	81	5·71	+2·59	17	77·4	+0·4	60·6	—0·3	62	83	0·40	—4·01	13
Galle ..	86	91	8·17	+2·03	24	81·4	—1·5	75·5	—1·3	86	88	5·62	—3·19	21
Hambantota ..	82	90	4·27	+2·83	8	83·8	—2·8	75·4	—0·7	81	91	1·32	—1·44	10
Jaffna ..	79	82	0·41	—0·70	2	84·7	—1·5	78·8	—0·5	78	82	0·06	—2·47	1
Kandy ..	71	85	3·13	—1·61	22	81·1	—1·2	68·8	+1·3	68	85	1·85	—4·13	20
Kankesanturai ..	69	93	0·19	—1·07	2	89·0	—0·9	78·4	—0·8	71	86	1·05	—1·92	2
Kurunegala	68	86	1·34	—2·28	15	87·8	+0·1	74·9	+0·6	69	88	1·93	—3·62	11
Mannar ..	75	82	0	—0·66	0	85·6	—2·1	78·3	—0·5	74	82	0·11	—1·13	2
Nuwara Eliya ..	85	88	6·11	—1·40	26	65·3	—1·6	55·3	+2·1	82	88	3·92	—4·32	24
Puttalam ..	68	82	0·01	—0·64	1	87·4	+0·4	77·8	0	66	80	0·11	—1·47	2
Ratmalana ..	73	84	3·42	—0·06	20	85·1	—0·6	77·1	+0·7	73	82	6·69	—0·15	22
Ratnapura ..	76	93	13·78	+2·39	28	85·8	—1·5	73·0	—0·5	76	93	17·64	+3·12	27
Talawakele ..	90	94	11·82	+1·24	28	67·9	—4·3	58·8	+0·5	—	97	7·73	—2·02	25
Trincomalee ..	60	76	7·21	+3·60	8	93·1	+1·0	77·1	0	59	78	5·95	+2·52	9